



US012216324B2

(12) **United States Patent**
Matsukawa et al.

(10) **Patent No.:** **US 12,216,324 B2**
(45) **Date of Patent:** **Feb. 4, 2025**

(54) **LENS BARREL**
(71) Applicant: **Panasonic Intellectual Property Management Co., Ltd., Osaka (JP)**

8,134,784 B2 3/2012 Kato
9,983,381 B2 5/2018 Shimizu
10,578,826 B2 3/2020 Hasegawa et al.
11,150,436 B2 10/2021 Matsushita et al.
2002/0141078 A1* 10/2002 Koivai G02B 7/04
359/822

(72) Inventors: **Takahiro Matsukawa, Osaka (JP); Taku Ichikawa, Osaka (JP)**

(Continued)

(73) Assignee: **Panasonic Intellectual Property Management Co., Ltd., Osaka (JP)**

FOREIGN PATENT DOCUMENTS

CN 111694124 A 9/2020
JP 2006078827 A * 3/2006

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 335 days.

(Continued)

OTHER PUBLICATIONS

(21) Appl. No.: **17/334,853**

Notice of Reasons for Refusal dated Jan. 9, 2024 in corresponding Japanese Patent Application No. 2020-110586, with English Translation.

(22) Filed: **May 31, 2021**

(65) **Prior Publication Data**
US 2021/0405320 A1 Dec. 30, 2021

Primary Examiner — Mahidere S Sahle
(74) *Attorney, Agent, or Firm* — Renner, Otto, Boisselle & Sklar, LLP

(30) **Foreign Application Priority Data**
Jun. 26, 2020 (JP) 2020-110586

(57) **ABSTRACT**

(51) **Int. Cl.**
G02B 7/02 (2021.01)
G02B 7/04 (2021.01)
(52) **U.S. Cl.**
CPC **G02B 7/04** (2013.01); **G02B 7/021** (2013.01)

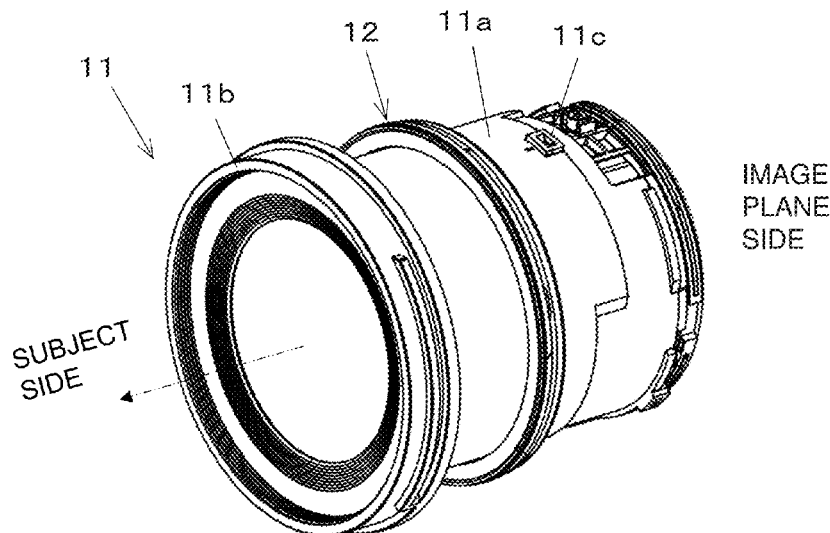
A lens barrel **10** comprises a substantially cylindrical first lens group unit **11** that holds a lens **L1**, and a substantially cylindrical front frame unit **12** that is disposed in a state of being close to the outer peripheral surface side of the substantially cylindrical first lens group unit **11**. The first lens group unit **11** has a rectilinear key **11c** that protrudes outward in the radial direction on the outer peripheral surface of the lens **L1** on the image plane side in the optical axis direction. The front frame unit **12** has an inside diameter that is smaller than the outside diameter of the first lens group unit **11** in the portion where the rectilinear key **11c** is provided. The first lens group unit **11** and the front frame unit **12** are formed so that a gap is formed between the outside diameter of the first lens group unit **11** and the inside diameter of the front frame unit **12** at a position opposite the rectilinear key **11c** in the radial direction.

(58) **Field of Classification Search**
CPC G02B 7/04; G02B 7/021
USPC 359/699–706, 825, 826, 830
See application file for complete search history.

(56) **References Cited**
U.S. PATENT DOCUMENTS

14 Claims, 27 Drawing Sheets

7,746,584 B2 6/2010 Honsho et al.
7,920,345 B2 4/2011 Honsho et al.



(56)

References Cited

U.S. PATENT DOCUMENTS

2004/0125225 A1* 7/2004 Noguchi G02B 7/021
348/335
2008/0180812 A1 7/2008 Honsho et al.
2010/0142939 A1 6/2010 Honsho et al.
2011/0026137 A1 2/2011 Kato
2016/0313534 A1 10/2016 Shimizu
2017/0343763 A1 11/2017 Hasegawa et al.
2020/0257075 A1* 8/2020 Matsushita G02B 7/04
2022/0187561 A1 6/2022 Chen et al.

FOREIGN PATENT DOCUMENTS

JP 2006-301291 A 11/2006
JP 2008-185786 A 8/2008
JP 2009-282393 A 12/2009
JP 2011-17790 A 1/2011
JP 2011-028093 A 2/2011
JP 4996269 B2 * 8/2012 G02B 15/173
JP 2015-179239 A 10/2015
JP 2016-051076 A 4/2016
JP 2021-117261 A 8/2021
WO WO-2016143326 A1 * 9/2016 G02B 15/15
WO 2019/087943 A1 5/2019

* cited by examiner

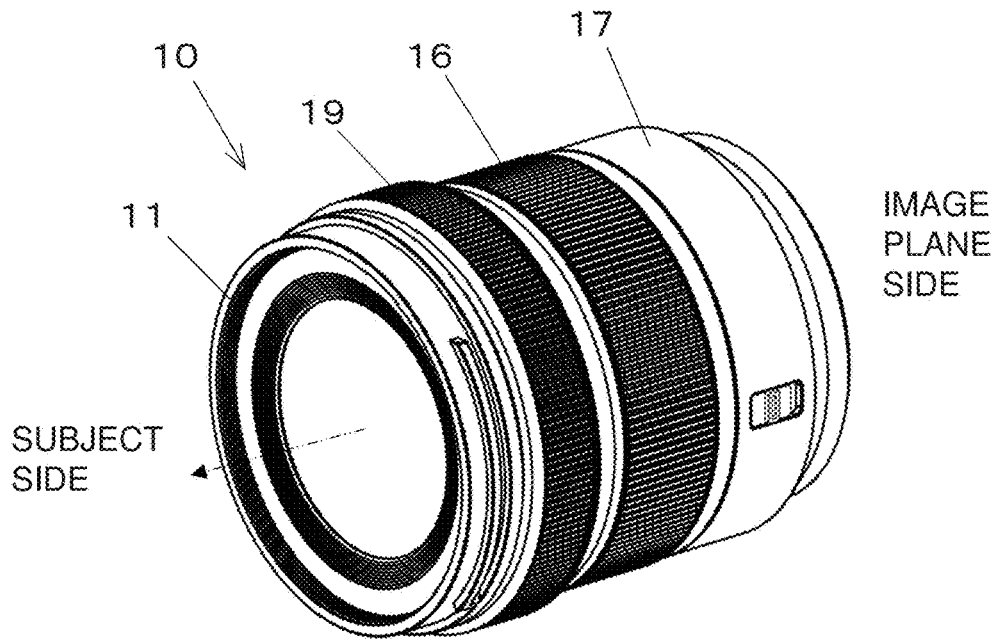


FIG. 1A

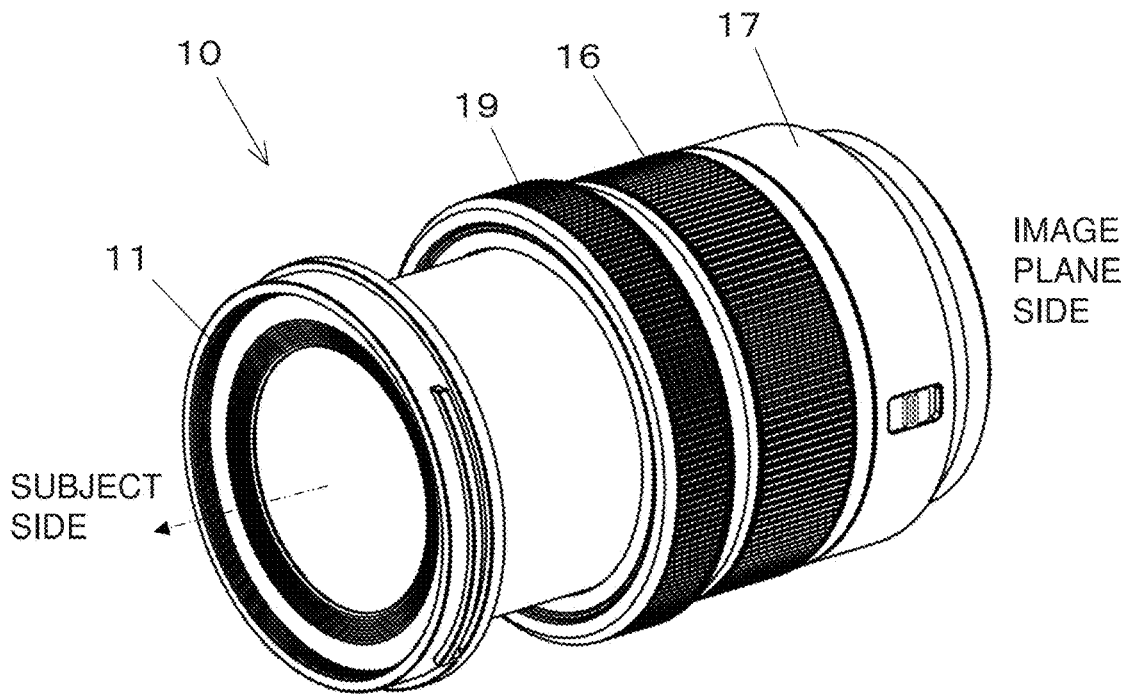


FIG. 1B

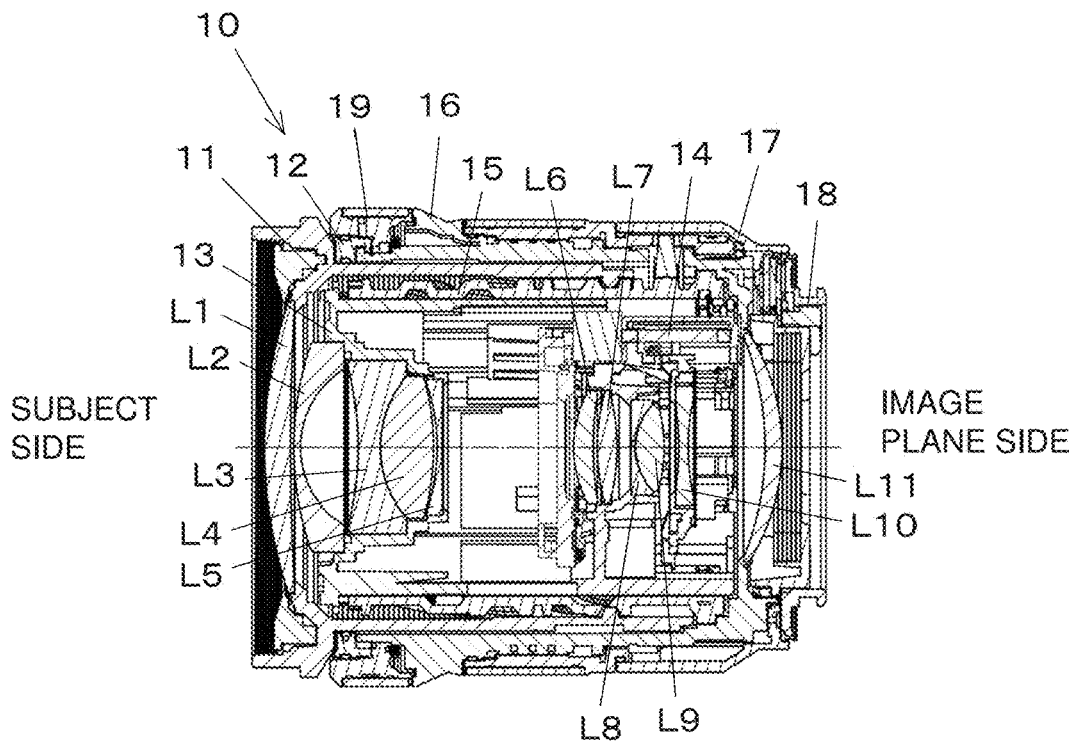


FIG. 2A

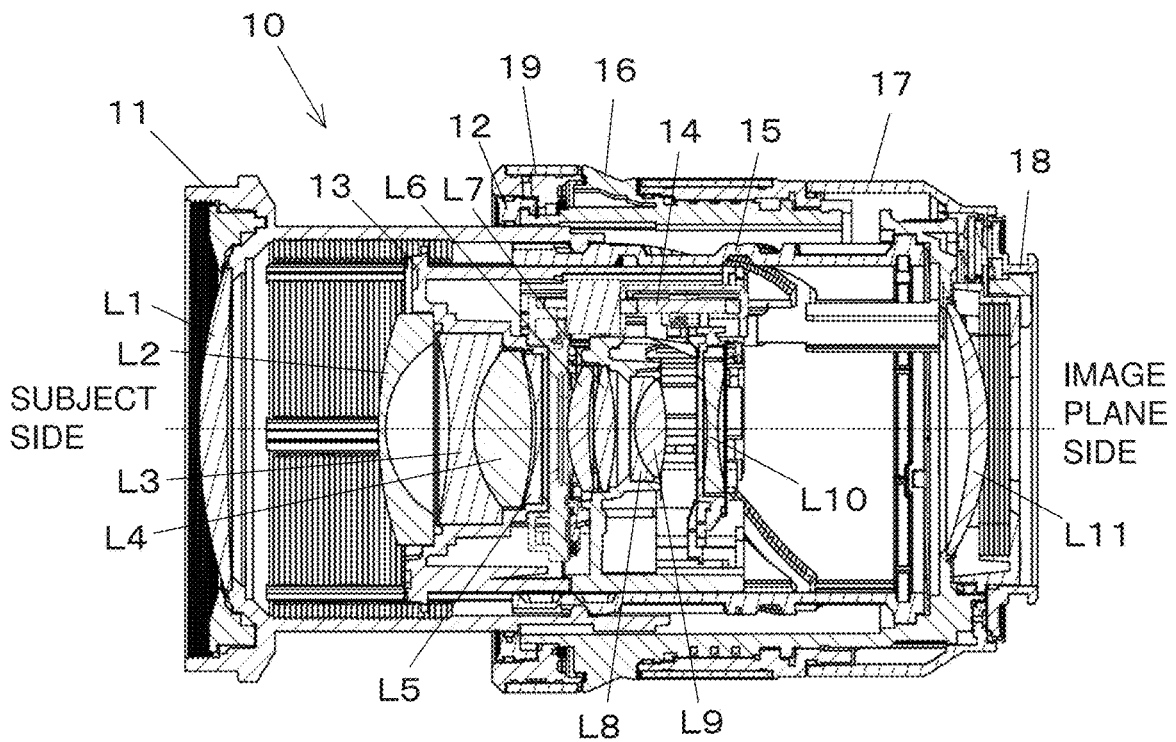


FIG. 2B

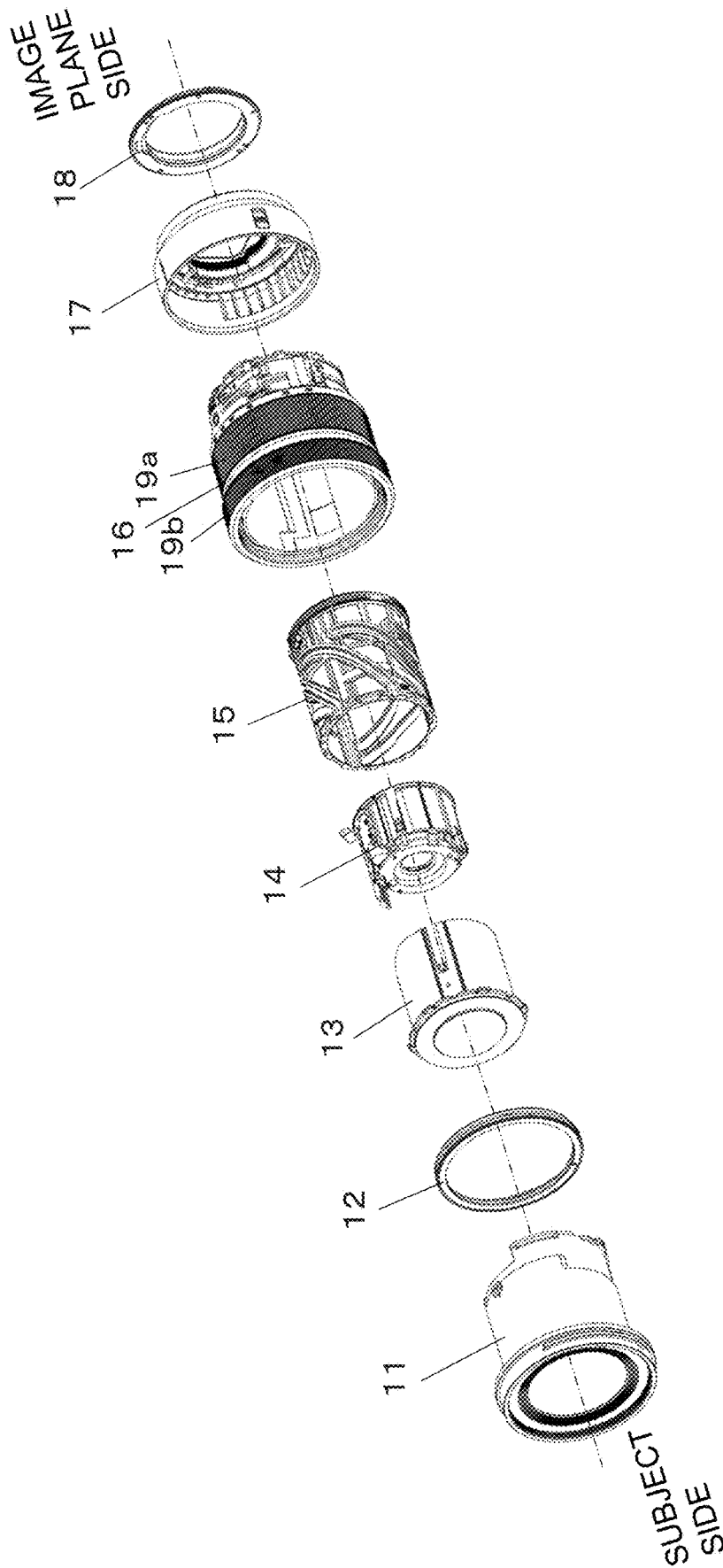


FIG. 3

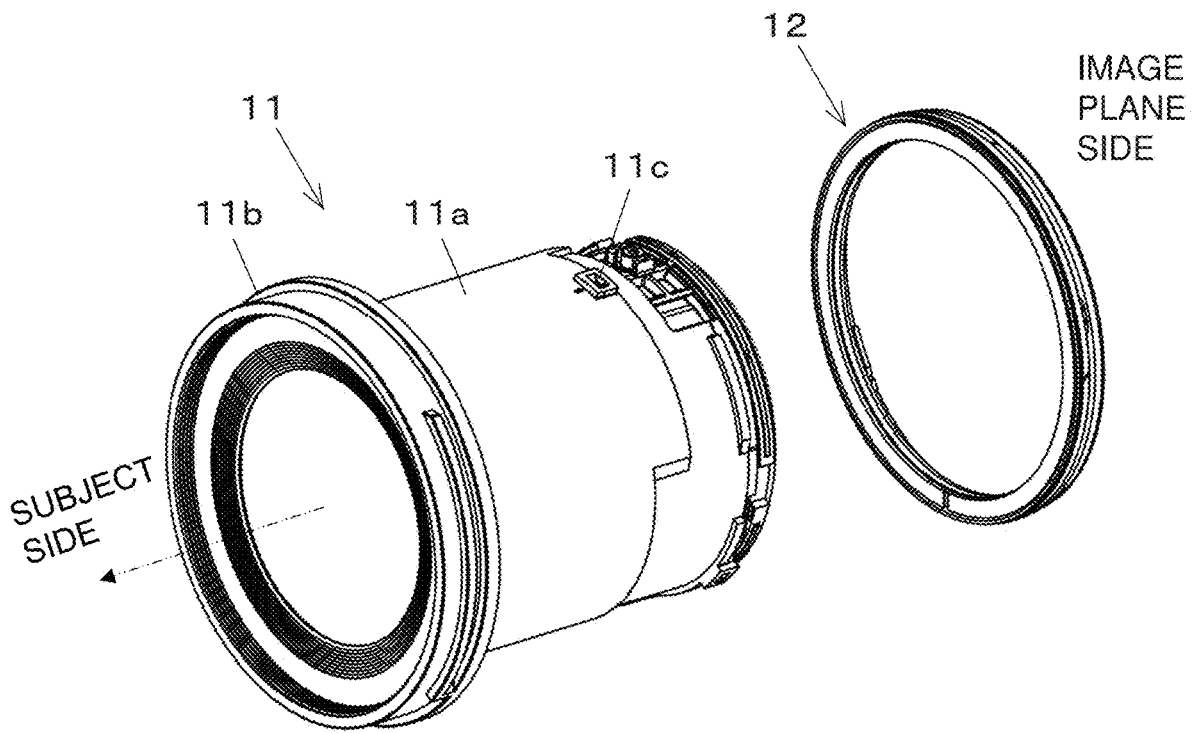


FIG. 4A

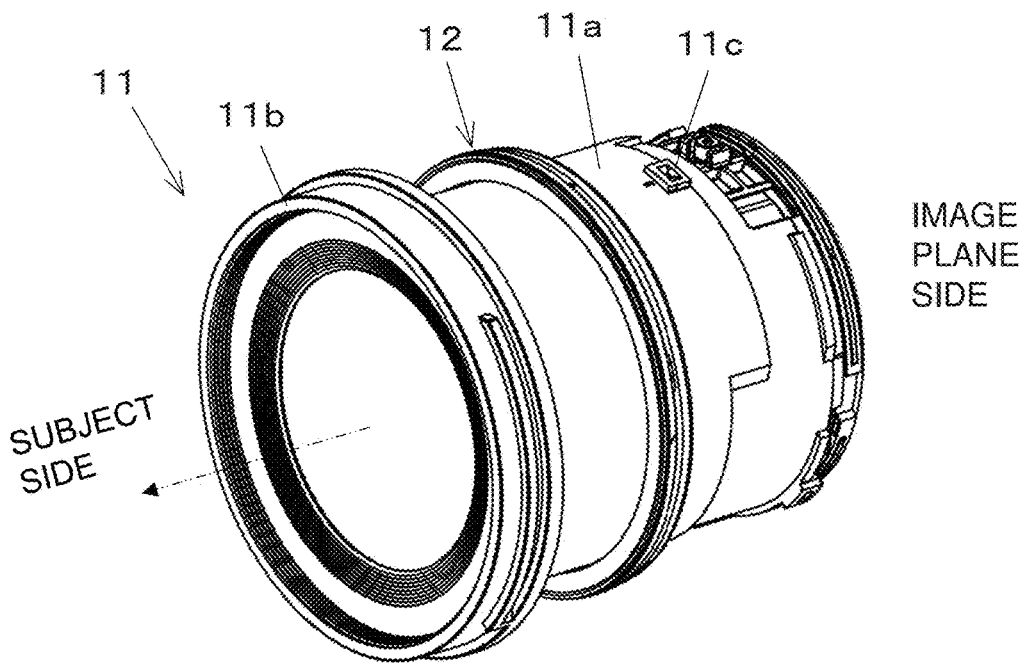


FIG. 4B

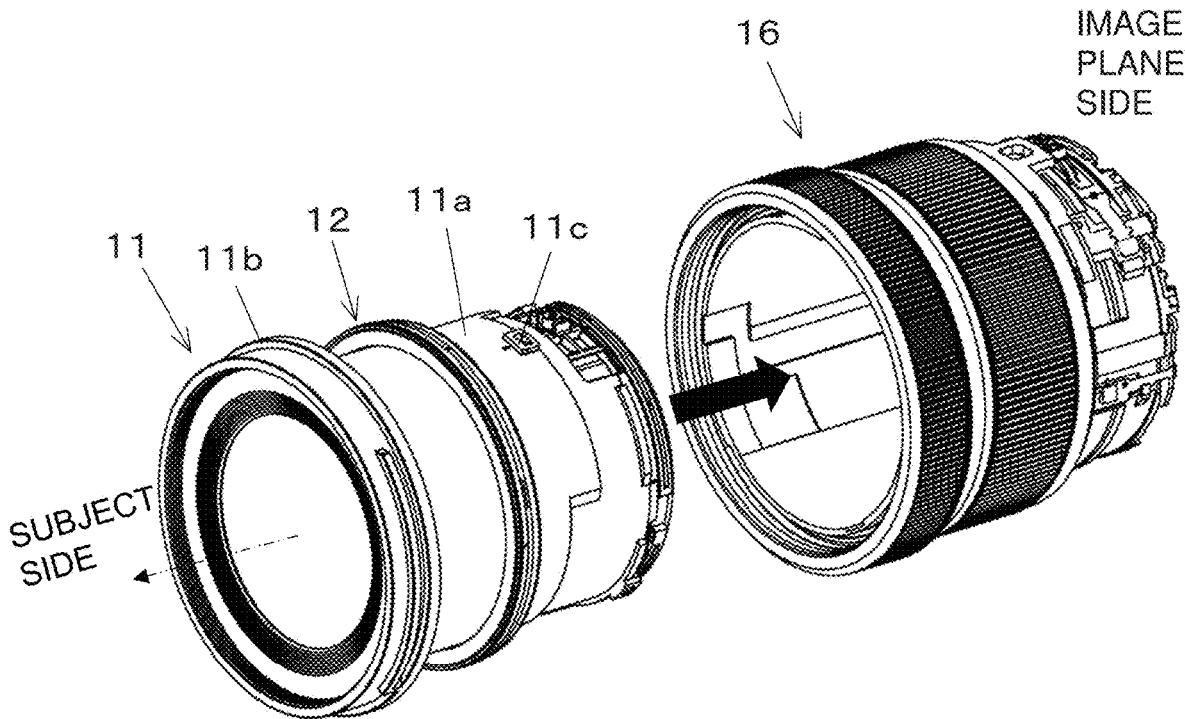


FIG. 5

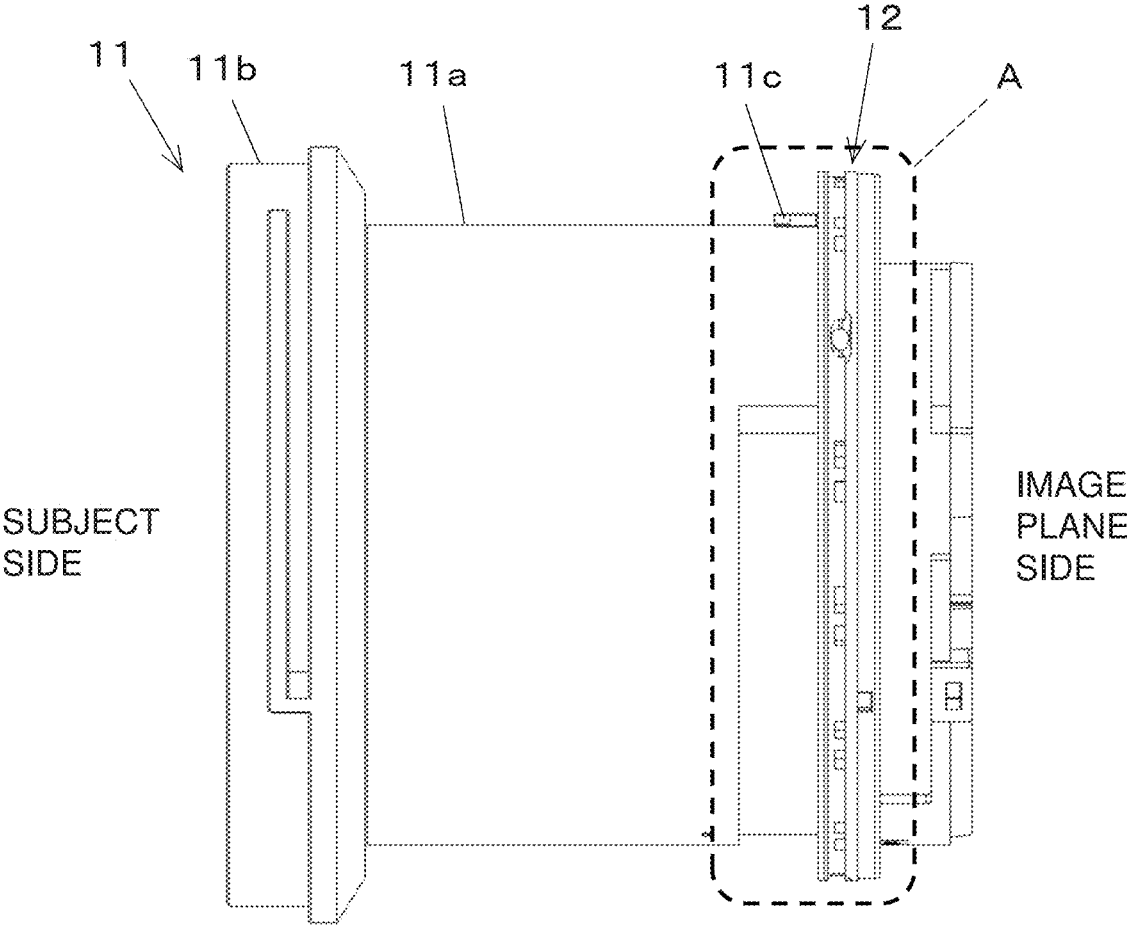
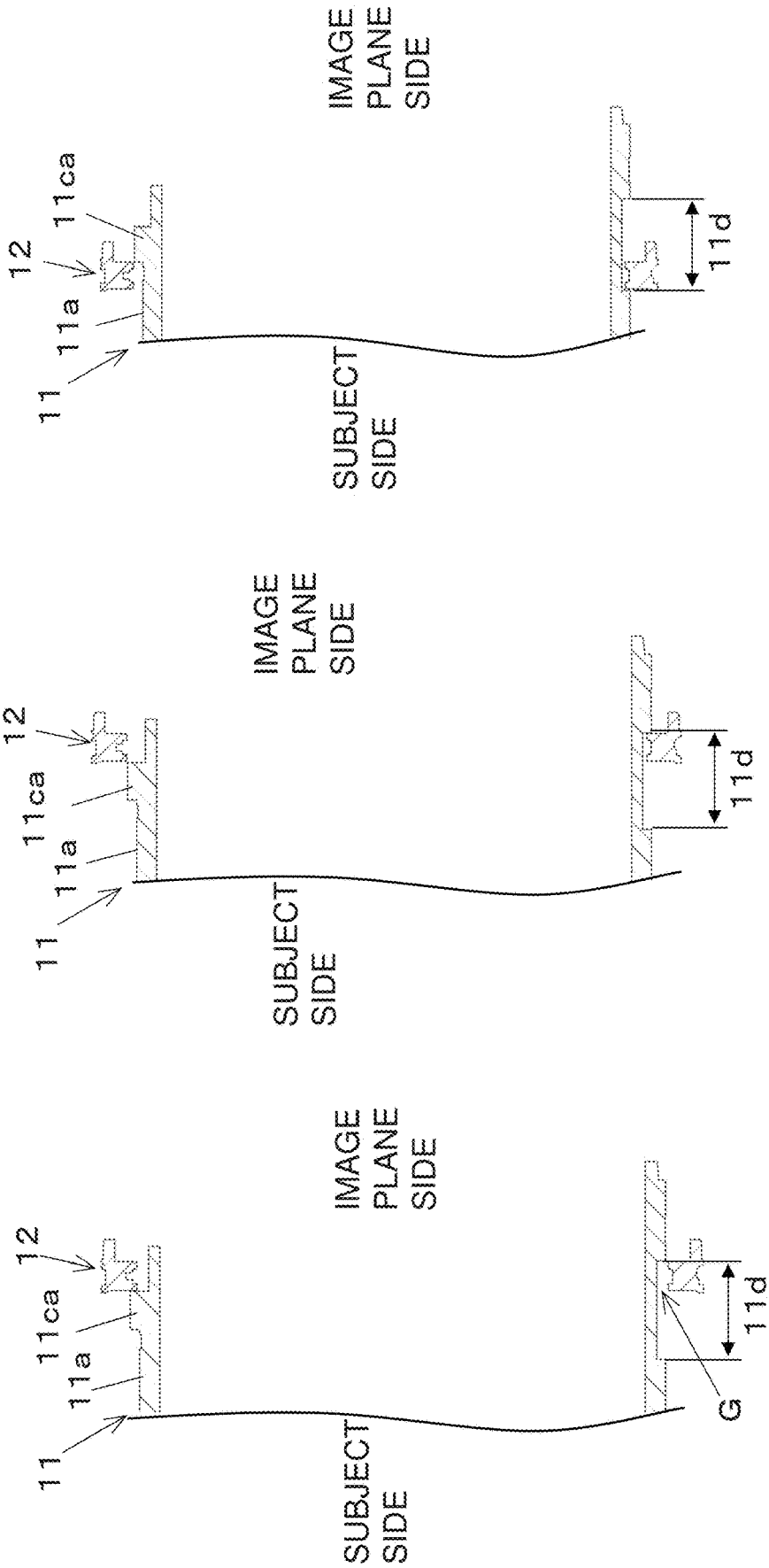


FIG. 6



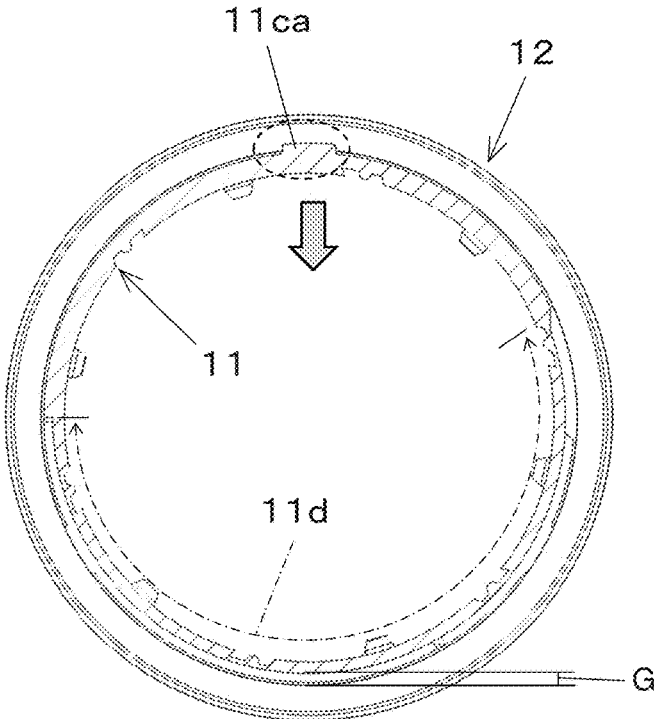


FIG. 8A

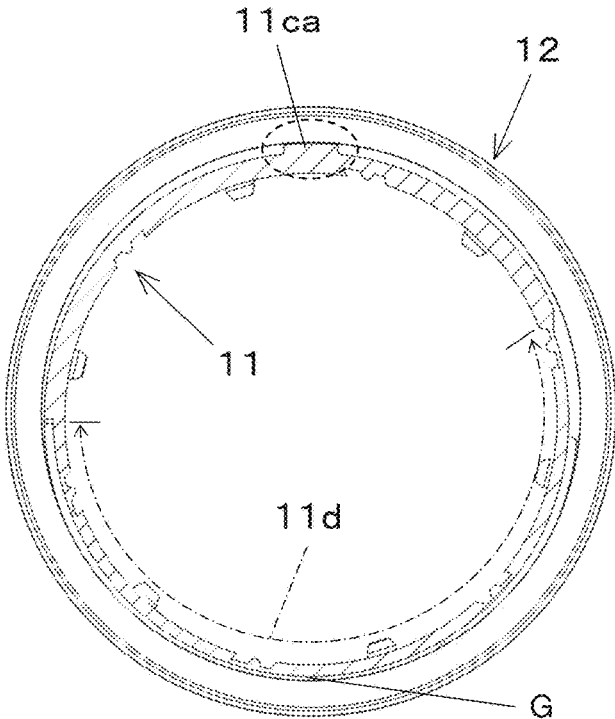


FIG. 8B

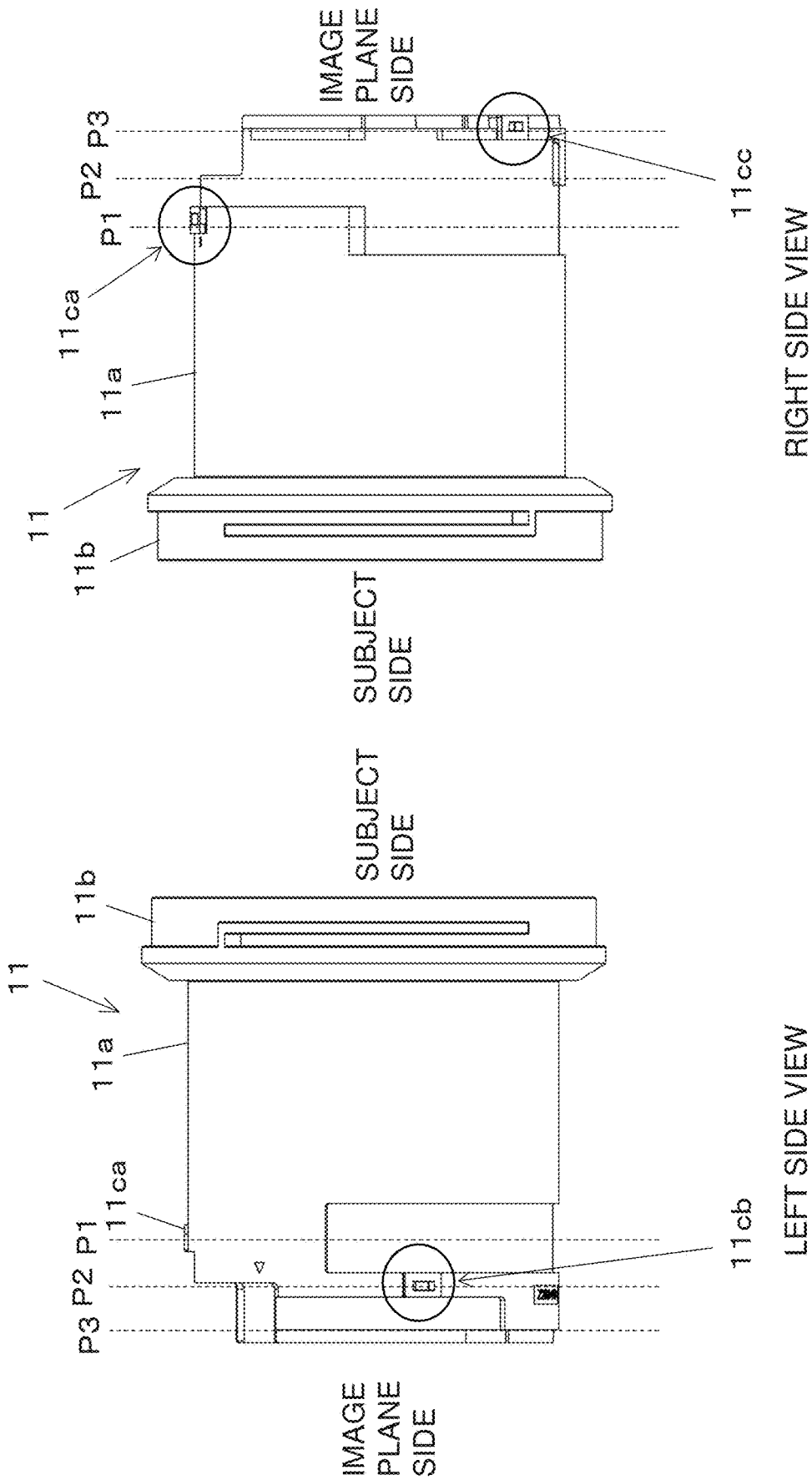
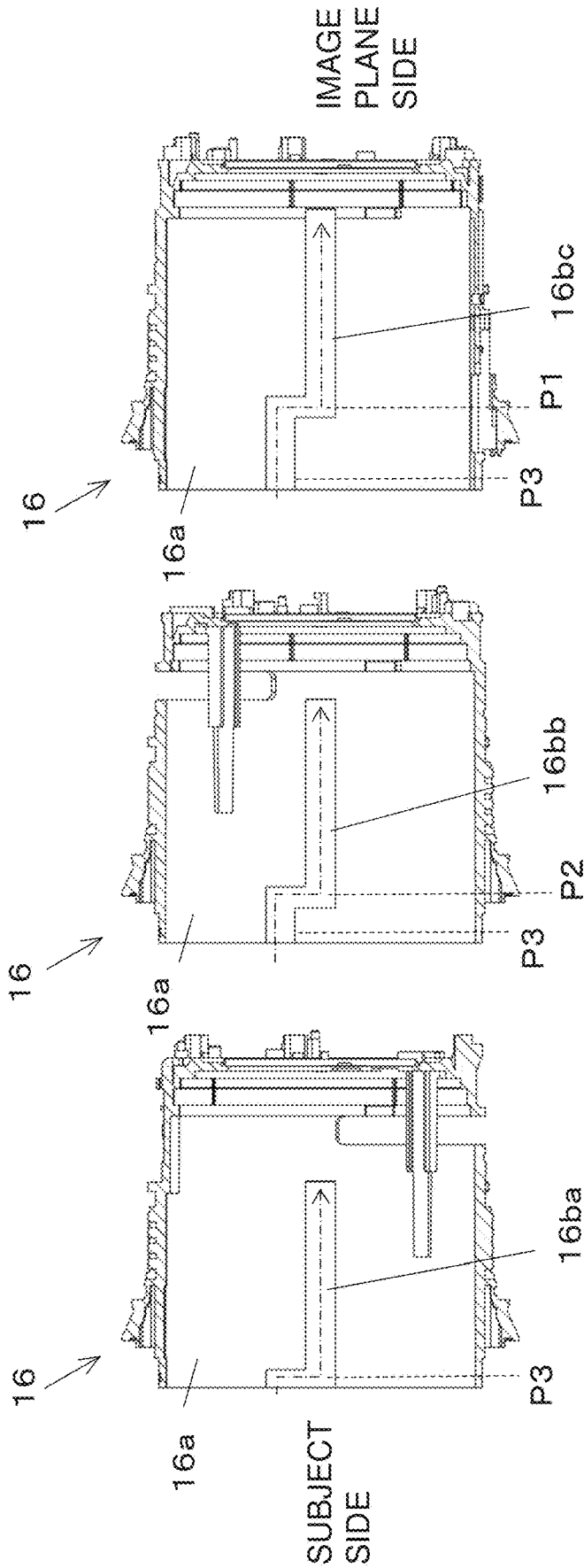


FIG. 9B

FIG. 9A



RECTILINEAR GROOVE OF
THIRD RECTILINEAR KEY
(Z-SHAPED)

RECTILINEAR GROOVE OF
SECOND RECTILINEAR KEY
(Z-SHAPED)

RECTILINEAR GROOVE OF
FIRST RECTILINEAR KEY
(L-SHAPED)

FIG. 10C

FIG. 10B

FIG. 10A

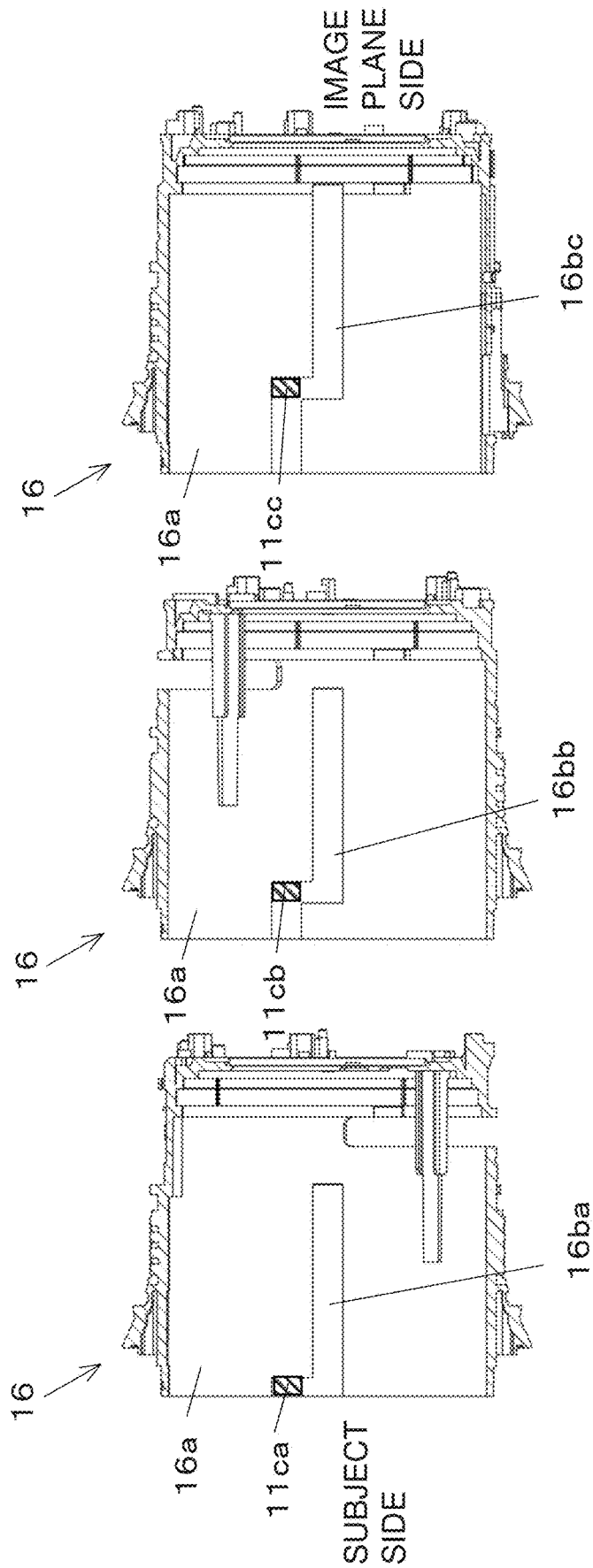


FIG. 11C

FIG. 11B

FIG. 11A

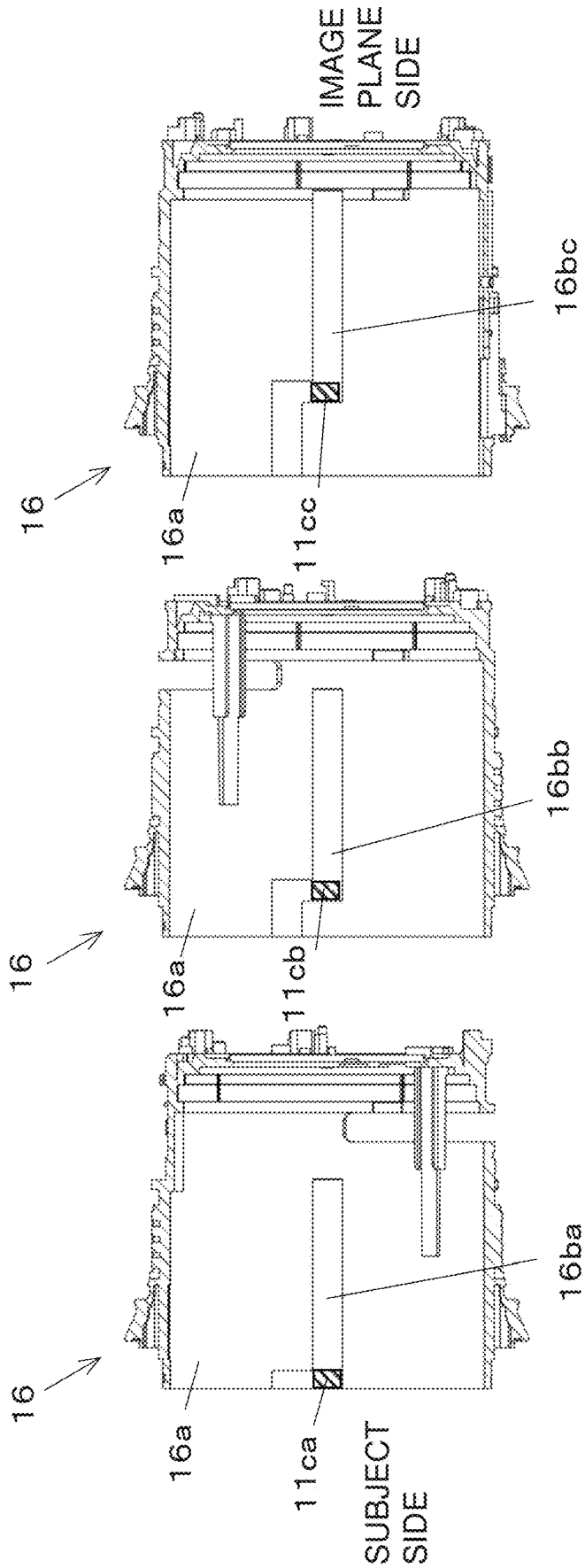


FIG. 12A

FIG. 12B

FIG. 12C

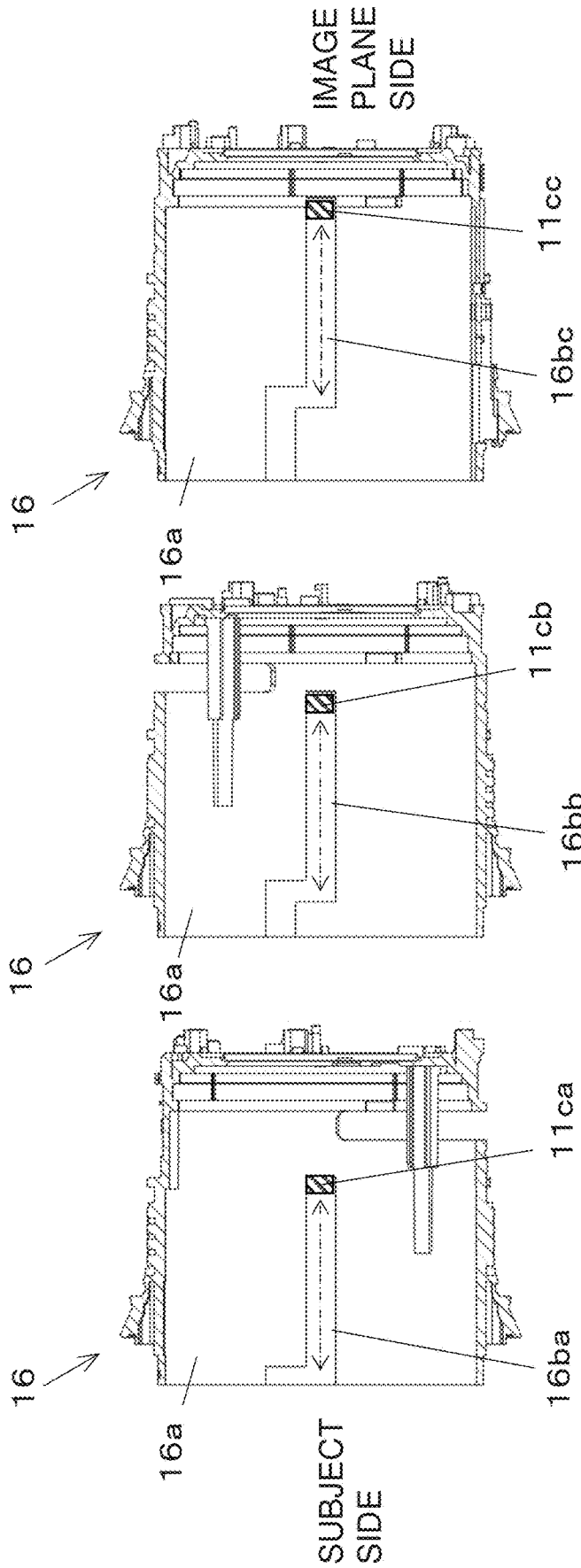


FIG. 13A

FIG. 13B

FIG. 13C

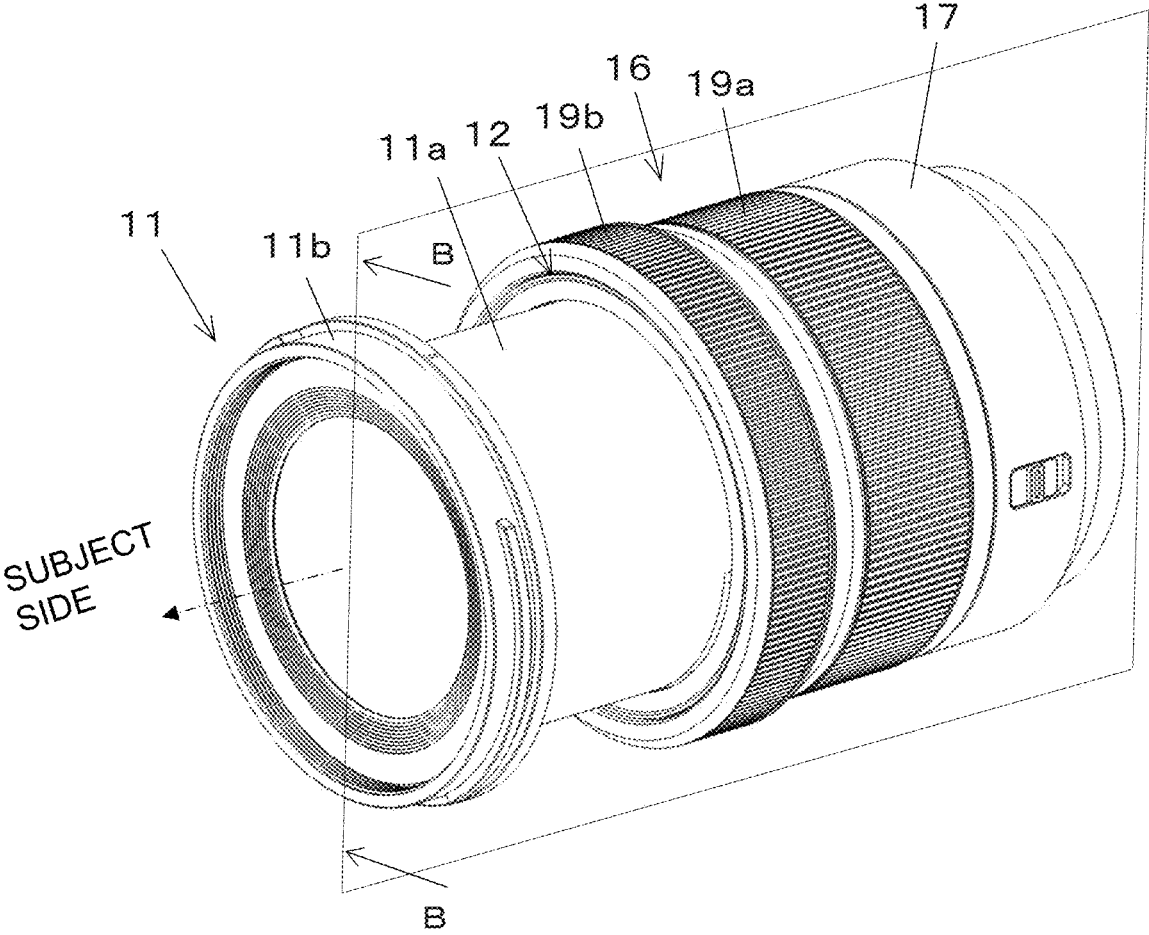


FIG. 14

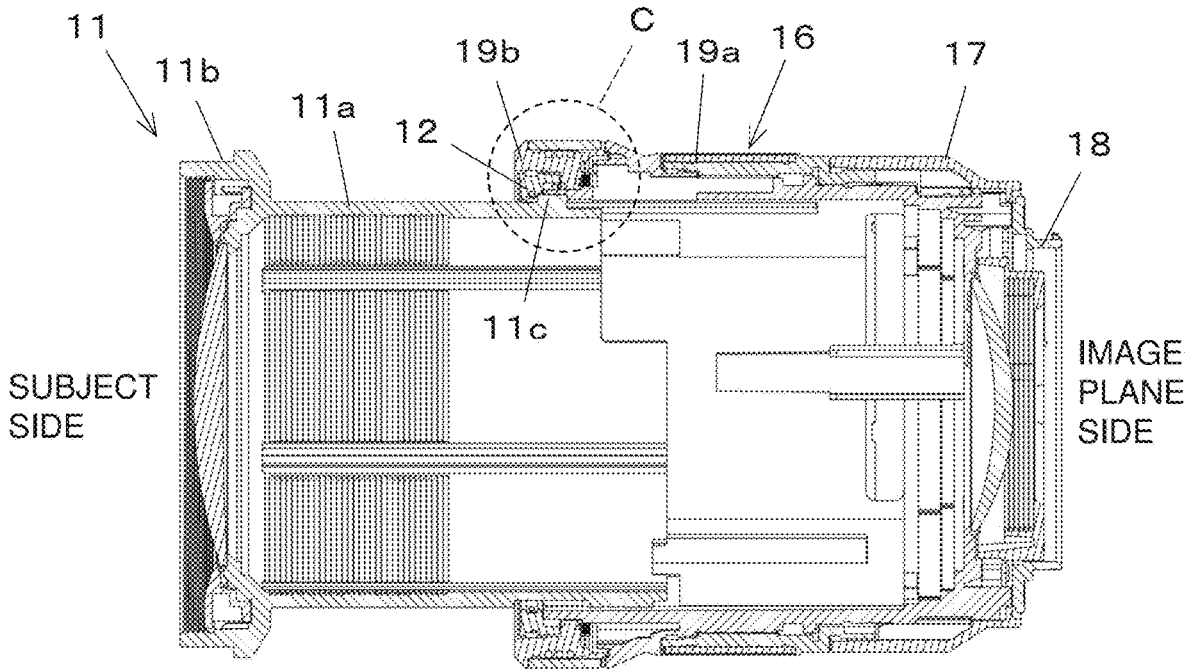


FIG. 15

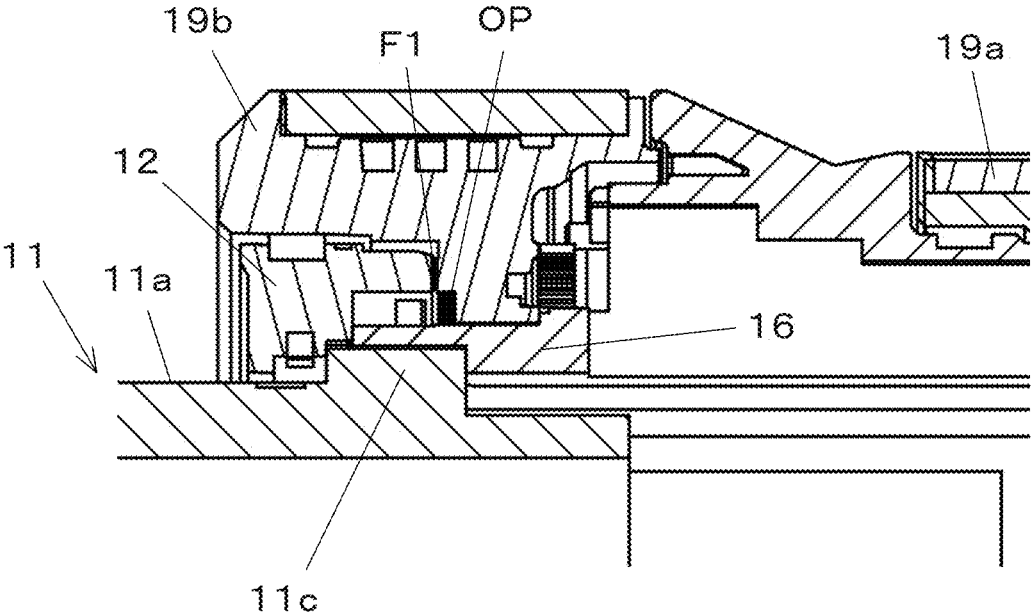


FIG. 16

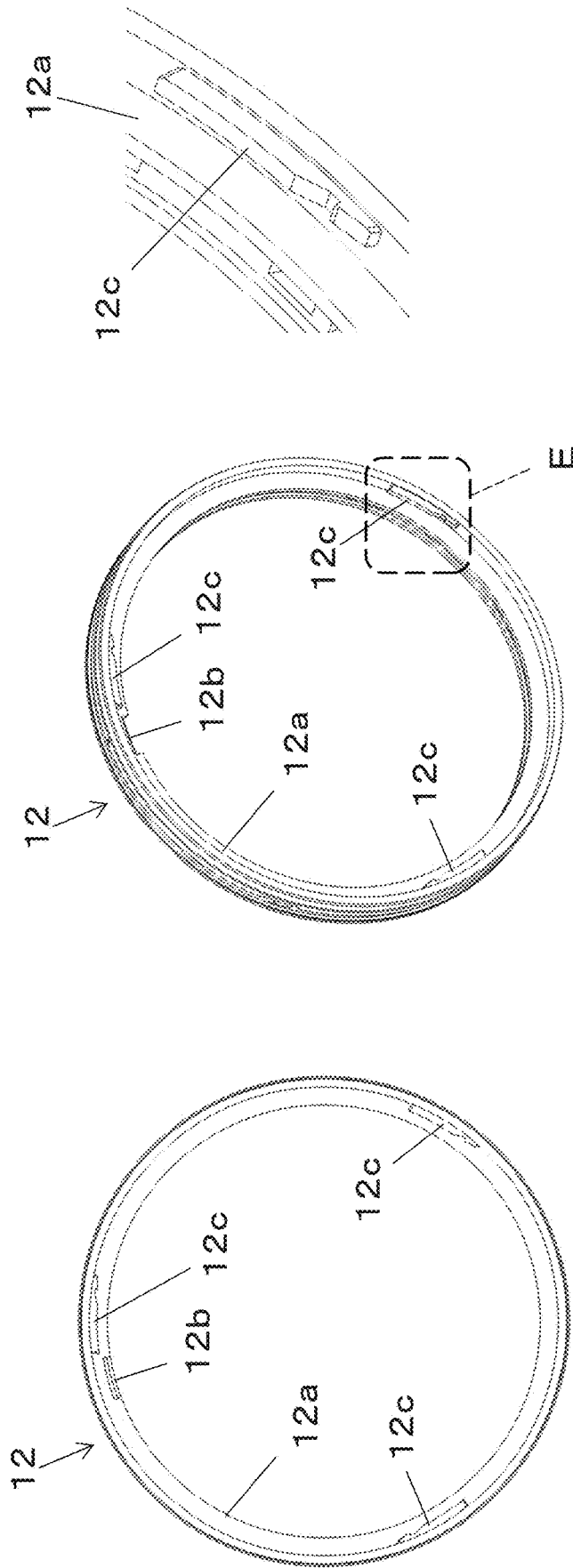


FIG. 17C

FIG. 17B

FIG. 17A

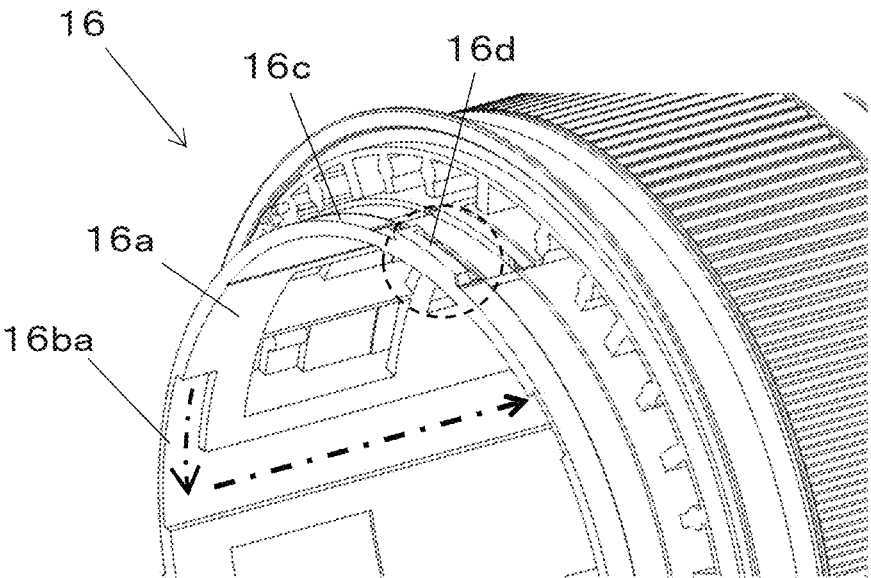


FIG. 18

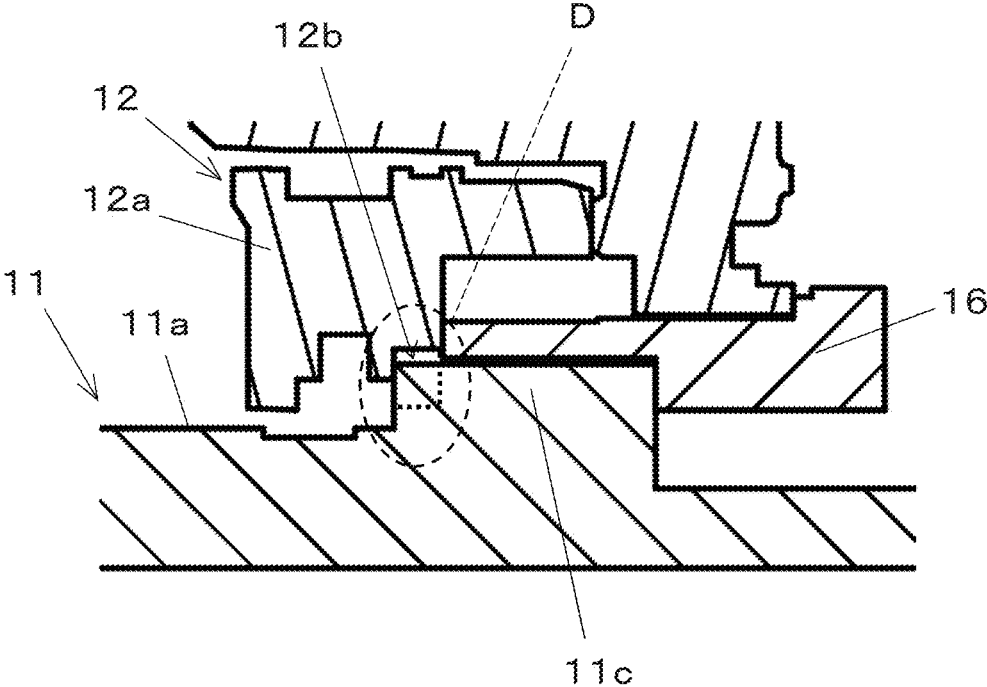


FIG. 19

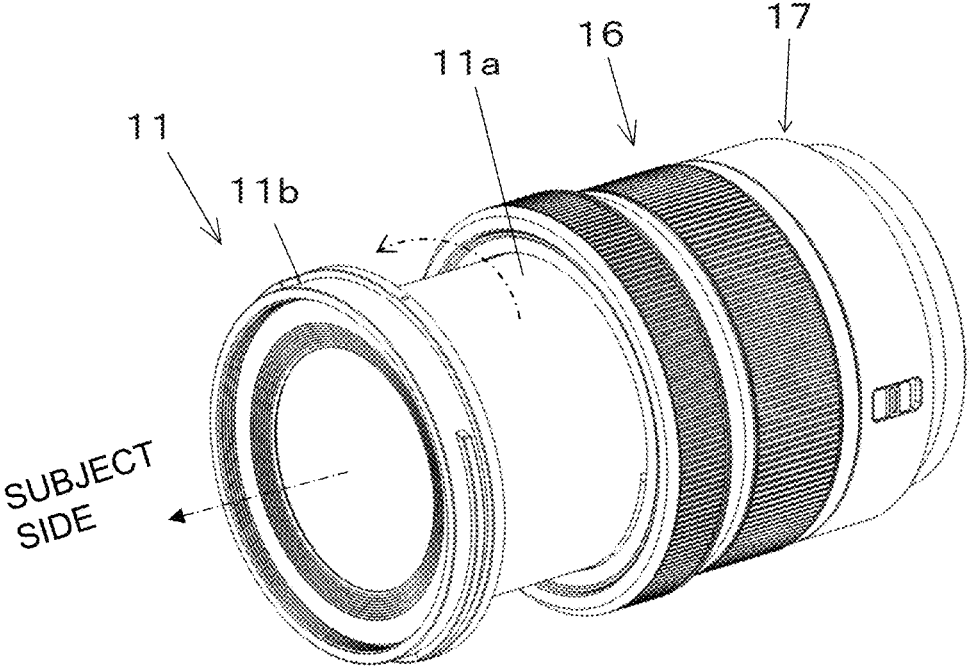


FIG. 20

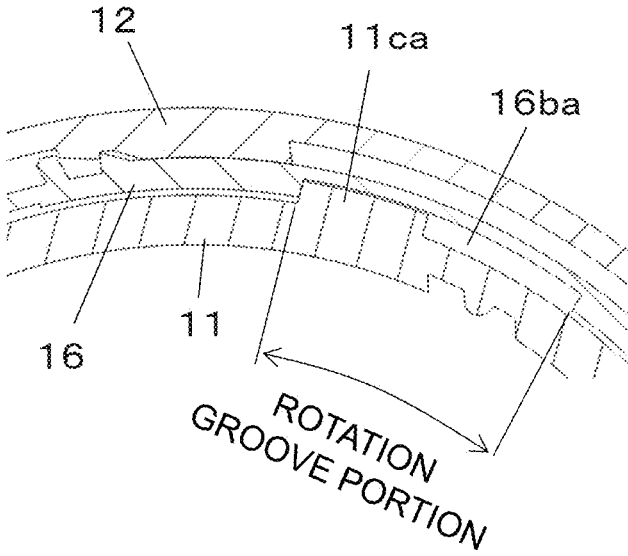


FIG. 21

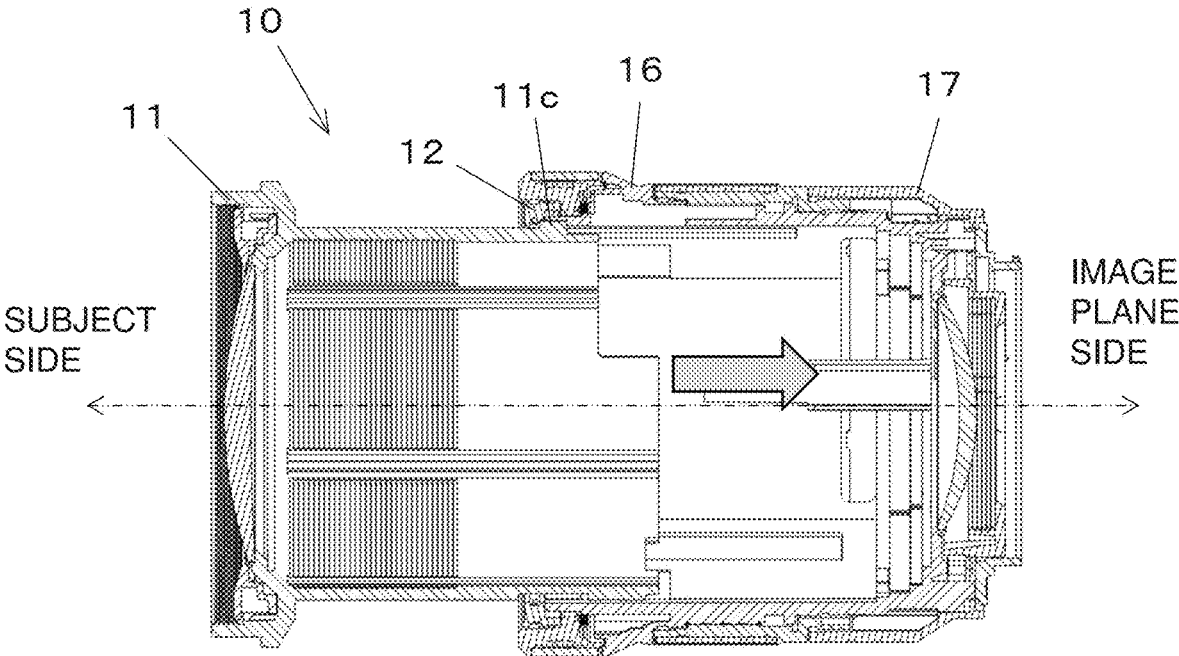


FIG. 22

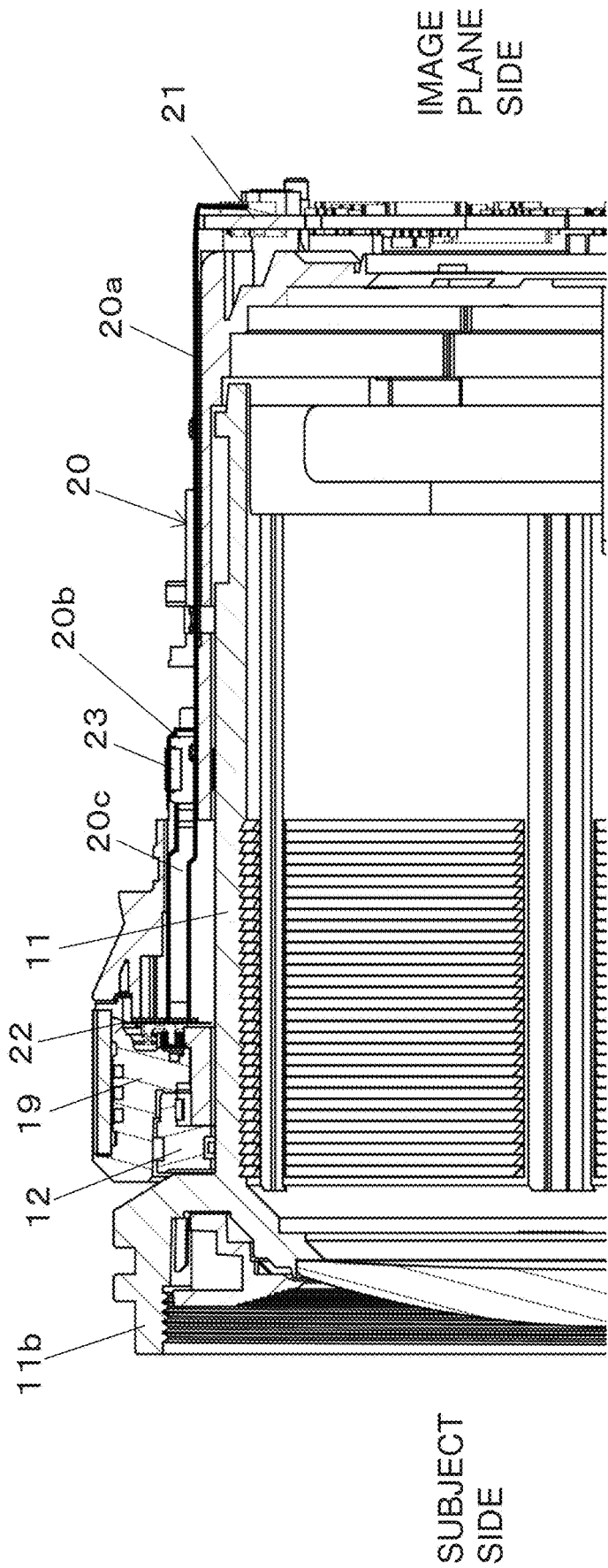


FIG. 23

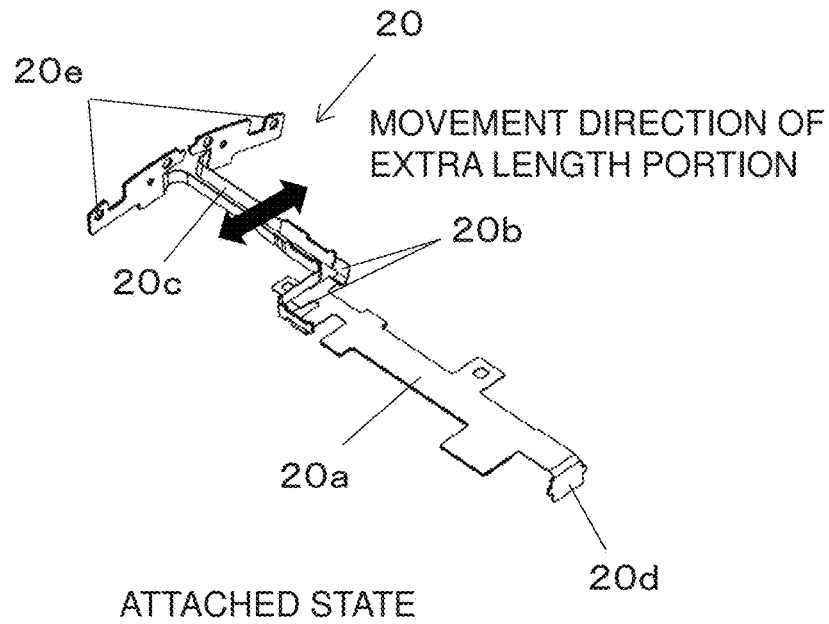


FIG. 24A

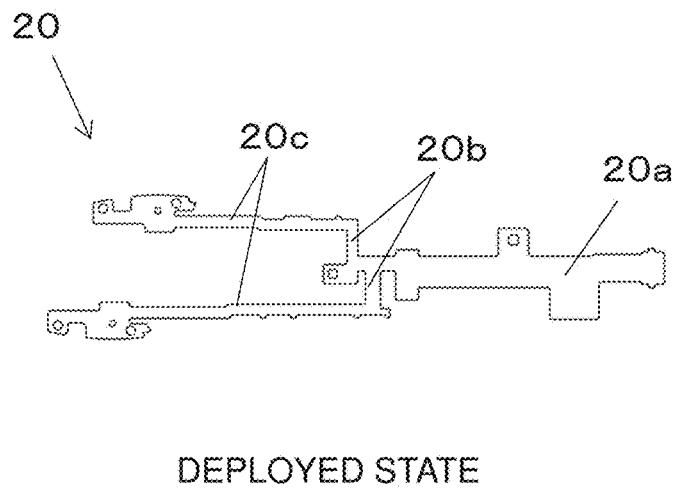


FIG. 24B

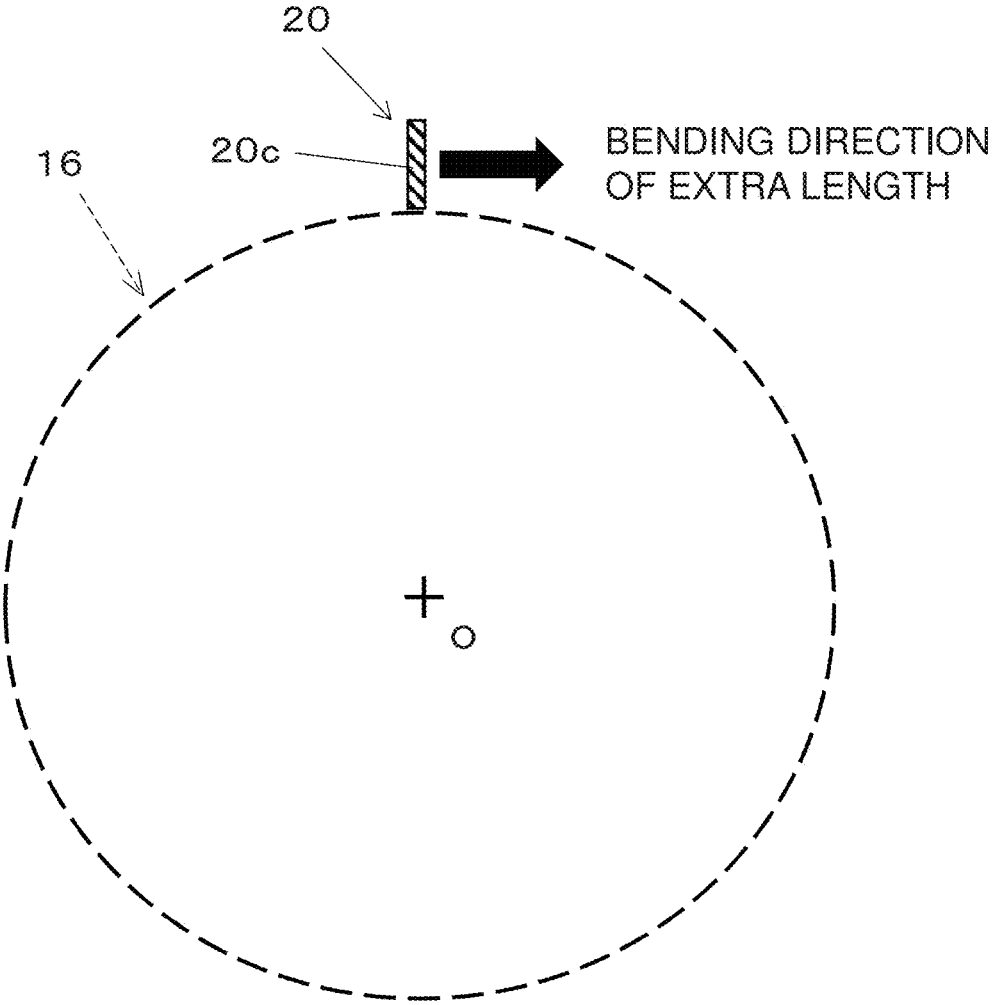


FIG. 25

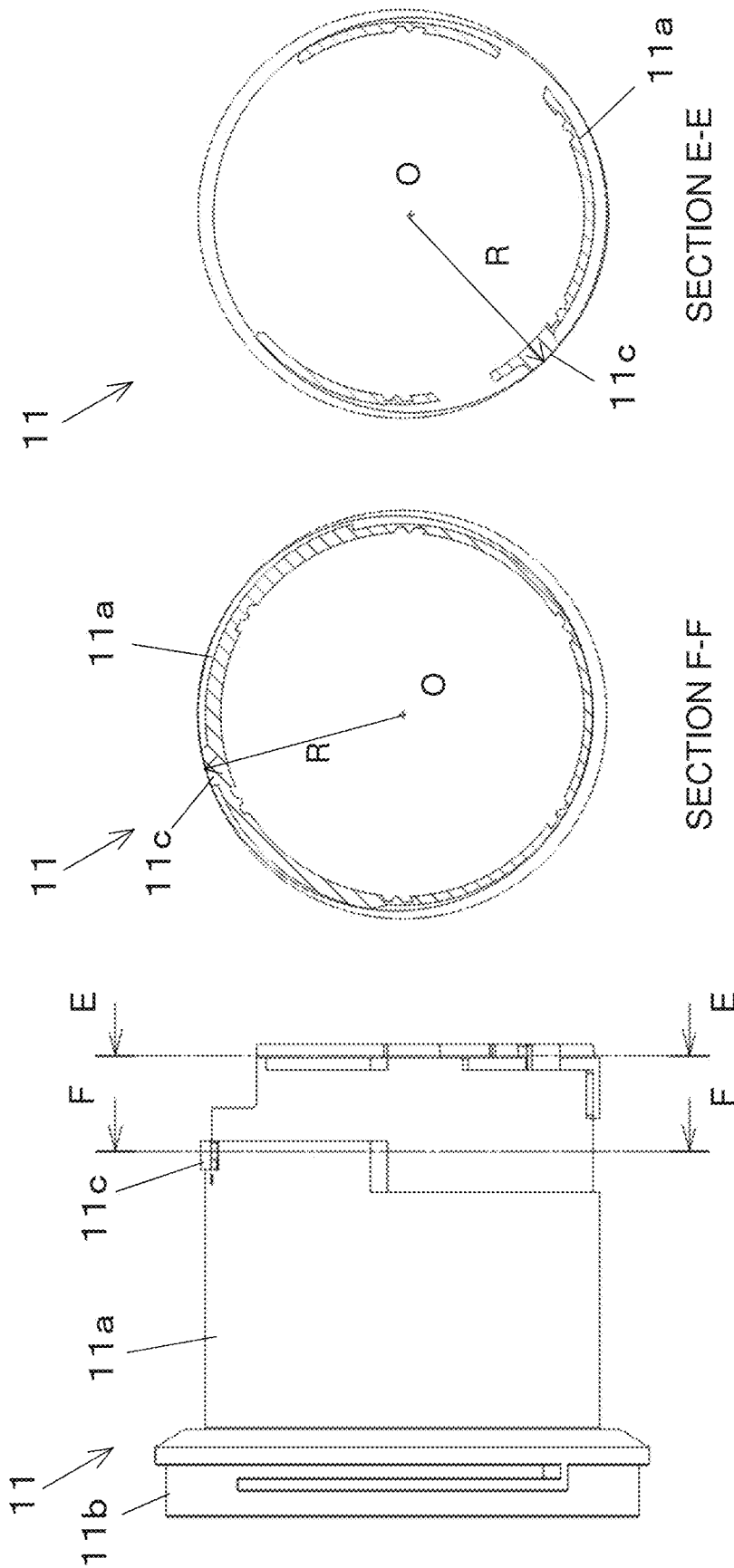


FIG. 26C

FIG. 26B

FIG. 26A

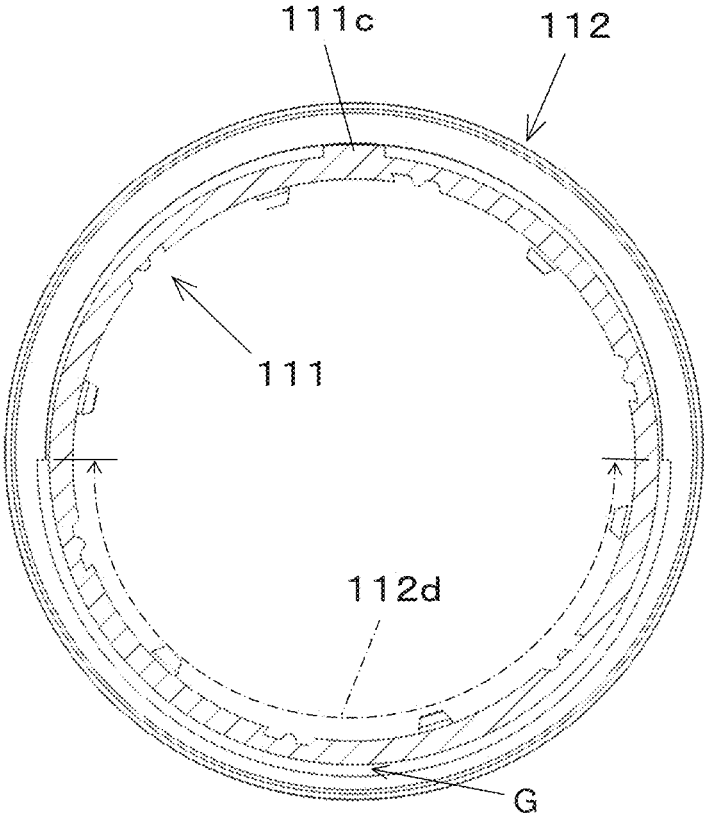


FIG. 27

1

LENS BARREL**CROSS-REFERENCE TO RELATED APPLICATIONS**

This application claims priority to Japanese Patent Application No. 2020-110586 filed on Jun. 26, 2020. The entire disclosure of Japanese Patent Application No. 2020-110586 is hereby incorporated herein by reference.

BACKGROUND**Technical Field**

The present disclosure relates to a lens barrel.

Description of the Related Art

A lens barrel constituted by a combination of substantially cylindrical members including a plurality of lenses is attached to a digital camera or another such imaging device.

For example, Patent Literature 1 discloses a lens barrel comprising a first frame and a second frame that is inserted into the first frame and provided so as to be capable of relative motion in the optical axis direction.

With this lens barrel, the first frame and the second frame are provided with n number of rectilinear guide recesses that extend in the optical axis direction and are disposed at angular positions that substantially divide the circumferential direction into n number of equal parts, and n number of rectilinear guide protrusions that movably engage with the rectilinear guide recesses. From one to $(n-1)$ of these n number of rectilinear guide recesses are provided to the first frame, the rest being provided to the second frame. The n number of rectilinear guide protrusions are provided to a different frame from the frame provided with the engaging rectilinear guide recesses. (Here, n is an integer of 2 or more).

Also, Patent Literature 2 discloses a lens barrel comprising a cylindrical first lens holder that holds a first lens group; a cylindrical second lens holder that holds a second lens group; a cam cylinder on the inner peripheral surface of which is formed an inner cam groove for driving one of the first lens holder and the second lens holder, and on the outer peripheral surface of which is formed an outer cam groove for driving the other of the first lens holder and the second lens holder; a first rectilinear guide that restricts the rotation of the first lens holder around the optical axis or around an axis parallel to the optical axis; and a second rectilinear guide that restricts the rotation of the second lens holder around the optical axis or around an axis parallel to the optical axis, and in which relative movement is restricted with respect to the first rectilinear guide in the circumferential direction around the rotational axis of the cam cylinder.

CITATION LIST**Patent Literature**

Patent Literature 1: JP-A 2015-179239

Patent Literature 2: JP-A 2011-17790

SUMMARY

However, the following problems are encountered with the conventional lens barrel discussed above.

2

That is, with a lens barrel constituted by a combination of a plurality of cylindrical parts, such as the lens barrel disclosed in the above-mentioned publications, the outside diameter imposes limitations, which makes it necessary to use a configuration combining a plurality of parts, or to make the inside diameter of the cylindrical parts on the incorporating side slightly larger than the outside diameter of the cylindrical parts on the incorporated side, or to use some other such means.

It is an object of the present disclosure to provide a lens barrel constituted by a combination of a plurality of cylindrical parts, wherein the number of parts can be reduced as compared to a conventional lens barrel.

The lens barrel disclosed herein comprises a substantially cylindrical first frame that holds a lens, and a substantially cylindrical second frame that is disposed in a state of being close to the outer peripheral surface side of the substantially cylindrical first frame. The first frame has a protrusion protruding outward in the radial direction on the outer peripheral surface of the lens on the image plane side in the optical axis direction. The second frame has an inside diameter that is smaller than the outside diameter of the first frame in the portion where the protrusion is provided. The first frame and the second frame are formed so that a gap is formed between the outside diameter of the first frame and the inside diameter of the second frame at a position opposite the protrusion in the radial direction.

TECHNICAL EFFECTS

With the lens barrel disclosed herein, the number of parts in a lens barrel constituted by combining a plurality of cylindrical parts can be reduced as compared with a conventional lens barrel.

BRIEF DESCRIPTION OF DRAWINGS

FIG. 1A is an oblique view of the configuration in a wide-angle state of the lens barrel according to an embodiment of this disclosure;

FIG. 1B is an oblique view of the configuration in a telephoto state of the lens barrel in FIG. 1A;

FIG. 2A is a cross-sectional view of the lens barrel in the wide-angle state in FIG. 1A;

FIG. 2B is a cross-sectional view of the lens barrel in the telephoto state in FIG. 1B;

FIG. 3 is an oblique view of the configuration of the lens barrel in FIG. 1A;

FIG. 4A is an oblique view of the state before the front frame unit is attached to the first lens group unit included in the lens barrel in FIG. 1A;

FIG. 4B is an oblique view of the state after the front frame unit has been attached to the first lens group unit included in the lens barrel in FIG. 1A;

FIG. 5 is an oblique view of the state before the configuration shown in FIG. 4B is inserted on the inner peripheral surface side of the exterior unit;

FIG. 6 is a side view of the state after the front frame unit has been attached to the first lens group unit shown in FIG. 4B;

FIG. 7A is a cross-sectional view of the state before the offset of the A portion in FIG. 6;

FIG. 7B is a cross-sectional view of the state after the offset of the A portion in FIG. 6;

FIG. 7C is a cross-sectional view of the state after assembly of the A portion in FIG. 6;

3

FIG. 8A is a front view of the state before offset in which the rectilinear key of the first lens group unit interferes with the inner peripheral surface of the front frame unit in the attachment of the front frame unit to the first lens group unit shown in FIG. 4B;

FIG. 8B is a front view of the state after offset so that the rectilinear key of the first lens group unit will not interfere with the inner peripheral surface of the front frame unit in the attachment of the front frame unit to the first lens group unit shown in FIG. 4B;

FIG. 9A is a left side view of a second rectilinear key formed on the outer peripheral surface of the first lens group unit shown in FIG. 4B;

FIG. 9B is a right side view of a first rectilinear key and a third rectilinear key formed on the outer peripheral surface of the first lens group unit shown in FIG. 4B;

FIG. 10A is a development view of the inner peripheral surface of an exterior unit, showing a first rectilinear groove that engages with the first rectilinear key shown in FIG. 9B;

FIG. 10B is a development view of the inner peripheral surface of an exterior unit, showing a second rectilinear groove that engages with the second rectilinear key shown in FIG. 9A;

FIG. 10C is a development view of the inner peripheral surface of an exterior unit, showing a third rectilinear groove that engages with the third rectilinear key shown in FIG. 9B;

FIG. 11A is a development view showing the position at the start of attachment of the first rectilinear key of the first lens group unit engaged with the first rectilinear groove of the exterior unit shown in FIG. 10A;

FIG. 11B is a development view showing the position at the start of attachment of the second rectilinear key of the first lens group unit engaged with the second rectilinear groove of the exterior unit shown in FIG. 10B;

FIG. 11C is a development view showing the position at the start of attachment of the third rectilinear key of the first lens group unit engaged with the third rectilinear groove of the exterior unit shown in FIG. 10C;

FIG. 12A is a developed view showing the position during rotation of the first rectilinear key of the first lens group unit engaged with the first rectilinear groove of the exterior unit shown in FIG. 10A;

FIG. 12B is a development view showing the position during rotation of the second rectilinear key of the first lens group unit engaged with the second rectilinear groove of the exterior unit shown in FIG. 10B;

FIG. 12C is a development view showing the position during rotation of the third rectilinear key of the first lens group unit engaged with the third rectilinear groove of the exterior unit shown in FIG. 10C;

FIG. 13A is a development view showing the position after attachment of the first rectilinear key of the first lens group unit engaged with the first rectilinear groove of the exterior unit shown in FIG. 10A;

FIG. 13B is a development view showing the position after attachment of the second rectilinear key of the first lens group unit engaged with the second rectilinear groove of the exterior unit shown in FIG. 10B;

FIG. 13C is a development view showing the position after attachment of the third rectilinear key of the first lens group unit engaged with the third rectilinear groove of the exterior unit shown in FIG. 10C;

FIG. 14 is an oblique view of the lens barrel in the telephoto state in FIG. 1B;

FIG. 15 is a cross-sectional view along the B-B plane in FIG. 14;

4

FIG. 16 is a detail view of the configuration of the C portion in FIG. 15;

FIG. 17A is a rear view of the configuration of the front frame unit;

5 FIG. 17B is an oblique view of the configuration of the front frame unit;

FIG. 17C is a detail view of the E portion in FIG. 17B;

10 FIG. 18 is an oblique view of a tab provided at the end of the exterior unit that engages with a groove provided to the front frame unit in the attachment of the exterior unit and the front frame unit to the outer peripheral surface of the first lens group unit shown in FIG. 5, and a rotary groove and a rectilinear groove in which a rectilinear key engages and rotates and advances;

15 FIG. 19 is a cross-sectional view of the configuration near the rectilinear key in the attachment of the front frame unit and the exterior unit to the outer peripheral surface of the first lens group unit shown in FIG. 5;

20 FIG. 20 is an oblique view of the state when the first lens group unit has been rotated with respect to the exterior unit in the attachment of the front frame unit and the exterior unit to the outer peripheral surface of the first lens group unit shown in FIG. 5;

25 FIG. 21 is a cross-sectional view of the state when the tab provided at the end of the exterior unit is engaged with and fixed to the grooves provided to the front frame unit in the attachment of the front frame unit and the exterior unit to the outer peripheral surface of the first lens group unit shown in FIG. 5;

30 FIG. 22 is a cross-sectional view of the state when the rectilinear key is guided by the rectilinear groove and the first lens group unit is accommodated in the exterior unit, in a state in which the front frame unit and the exterior unit have been attached to the outer peripheral surface of the first lens group unit shown in FIG. 5;

35 FIG. 23 is a cross-sectional view of an FPC provided to the exterior unit in FIG. 5;

FIG. 24A is an oblique view of the FPC in FIG. 23;

40 FIG. 24B is a plan view of the FPC in FIG. 24A in an expanded state;

FIG. 25 is a schematic view showing the direction in which the FPC in FIG. 24A bends according to the retraction of the lens barrel;

45 FIG. 26A is a side view of the configuration of the first lens group unit shown in FIG. 4B;

FIG. 26B is a cross-sectional view along F-F line in FIG. 26A;

50 FIG. 26C is a cross-sectional view along the E-E line in FIG. 26A; and

55 FIG. 27 is a front view of the state when the rectilinear key of the first lens group unit included in the lens barrel in another embodiment of this disclosure has been offset so as not to interfere with the inner peripheral surface of a front frame unit.

DETAILED DESCRIPTION OF THE INVENTION

60 Embodiments of the present disclosure will now be described through reference to the drawings. However, some unnecessarily detailed description may be omitted. For example, detailed description of already known facts or redundant description of components that are substantially the same may be omitted. This is to avoid unnecessary repetition in the following description, and facilitate an understanding on the part of a person skilled in the art.

65

The applicant has provided the appended drawings and the following description so that a person skilled in the art might fully understand this disclosure, but does not intend for these to limit what is discussed in the patent claims.

Embodiment 1

The lens barrel **10** according to an embodiment of the present disclosure will now be described with reference to FIGS. 1A to 26C.

(1) Configuration of Lens Barrel

As shown in FIGS. 1A and 1B, and FIGS. 2A and 2B, the lens barrel **10** according to this embodiment can be telescope between the wide-angle side and the telephoto side, and comprises an optical system including a plurality of lenses **L1** to **L11** disposed from the subject side to the image plane side in the optical axis direction; a first lens group unit (first frame) **11**; a front frame unit (second frame) **12**; a front frame unit (second frame) **12**; a second lens group unit **13**; a third/fourth lens group unit **14**; a cam frame unit **15**; an exterior unit (third frame) **16**; a rear frame unit **17**; and a lens mount **18**. The lens barrel **10** is mounted on the lens mount **18** side in a replaceable state on a mount portion of a camera body (not shown).

As shown in FIGS. 1A and 1B, and FIGS. 2A and 2B, the lens barrel **10** captures images at variable magnification by having the built-in optical system move in the optical axis direction of the lenses **L1** to **L11** between the wide-angle side and the telephoto side.

With the lens barrel **10**, when the optical system is located on the wide-angle side shown in FIGS. 1A and 2A, the first lens group unit **11** of the optical system (discussed below) is housed on the inner peripheral surface side of the exterior unit **16**.

Meanwhile, with the lens barrel **10**, when the optical system is located on the telephoto side shown in FIGS. 1B and 2B, the first lens group unit **11** moves toward the subject in the optical axis direction, and is deployed toward the subject from the exterior unit **16**.

As shown in FIG. 3, the lens barrel **10** comprises, in the following order starting from the subject side in the optical axis direction, the first lens group unit (first frame) **11**, the front frame unit (second frame) **12**, the second lens group unit **13**, the third/fourth lens group unit **14**, the cam frame unit **15**, the exterior unit (third frame) **16**, the rear frame unit **17**, and the lens mount **18**.

The first lens group unit **11** is a substantially cylindrical member, and a lens **L1** is disposed inside the first lens group unit **11** on the subject side as shown in FIGS. 2A and 2B. The first lens group unit **11** moves forward and backward in the optical axis direction in a state in which the lens **L1** is held on the subject side.

Consequently, the distance between the lenses **L1** and **L11** changes, allowing wide-angle and telephoto imaging to be performed.

The front frame unit (second frame) **12** is a substantially cylindrical (substantially annular) member that is disposed close to the outer peripheral surface of the substantially cylindrical first lens group unit **11**, and as shown in FIGS. 4A and 4B, it is attached to the first lens group unit **11** by an offset attachment structure (discussed below). Also, the front frame unit **12** moves in the optical axis direction in a state of being fixed to the end portion on the subject side of the exterior unit **16** (discussed below), and a state of being integrated with the exterior unit **16** with respect to the first lens group unit **11**. Also, the front frame unit **12** has an inner periphery having a substantially circular shape.

The offset attachment structure of the front frame unit **12** with respect to the first lens group unit **11** will be described in detail at a later point.

As shown in FIG. 3, the second lens group unit **13** is a member having a substantially cylindrical shape that is disposed on the inner peripheral surface side of the first lens group unit **11**, and holds the lenses **L2** to **L5** as shown in FIGS. 2A and 2B. The lenses **L2** to **L5** are disposed further to the image plane side in the optical axis direction than the lens **L1** held by the first lens group unit **11**.

The third/fourth lens group unit **14** is a member having a substantially cylindrical shape that is disposed on the inner peripheral surface side of the second lens group unit **13**, and holds the lenses **L6** to **L10** as shown in FIGS. 2A and 2B. The lenses **L6** to **L10** are disposed further to the image plane side in the optical axis direction than the lenses **L2** to **L5** held by the second lens group unit **13**. The third/fourth lens group unit **14** is driven by an actuator to move back and forth in the optical axis direction while holding the lenses **L6** to **L10**.

As shown in FIG. 3, the cam frame unit **15** is a member having a substantially cylindrical shape, and a cam groove is formed in the outer peripheral surface thereof. The cam frame unit **15** is disposed on the outer peripheral surface side of the second lens group unit **13** and the third/fourth lens group unit **14**. Cam pins provided on the outer peripheral surfaces of the second lens group unit **13** and the third/fourth lens group unit **14** are fitted into a cam groove of the cam frame unit **15**.

The cam pins of the second lens group unit **13** and the third/fourth lens group unit **14** move along the cam groove upon receiving a rotational drive force applied from a rotational drive source. Consequently, the first lens group unit **11**, the second lens group unit **13**, and the third/fourth lens group unit **14** can be moved back and forth in the optical axis direction.

As a result, the distance between the lenses **L1** to **L10** included in the first lens group unit **11**, the second lens group unit **13**, and the third/fourth lens group unit **14** can be adjusted, so wide-angle imaging, telephoto imaging, and the like can be performed.

As shown in FIGS. 3 and 5, the exterior unit (third frame) **16** is a member having a substantially cylindrical shape, which constitutes the exterior portion of the lens barrel **10**. An annular zoom ring **19a**, a focus ring **19b**, and the like are attached to the outer peripheral surface of the exterior unit **16** so as to be rotatable around the circumferential direction. The exterior unit **16** is provided with a circuit board **21** (see FIG. 23) and an FPC **20** (see FIG. 24A, etc.) that is electrically connected to the circuit board **21**, these being provided (discussed below) from the end face on the image plane side toward the subject side.

The attachment structure of the front frame unit **12** and the exterior unit **16** with respect to the first lens group unit **11** will be described in detail below.

The rear frame unit **17** is a member having a substantially cylindrical shape, which is attached to the end of the exterior unit **16** on the image plane side, and constitutes the exterior portion of the lens barrel **10** together with the exterior unit **16**.

The lens mount **18** is a substantially annular member that is attached to the end of the rear frame unit **17** on the image plane side, and is mounted in a replaceable state to the mount unit of a camera body (not shown).

(2) Offset Attachment Structure of Front Frame Unit **12** with Respect to First Lens Group Unit **11**

As described above, the lens barrel **10** in this embodiment comprises the substantially cylindrical first lens group unit

11 that holds the lens **L1**, and the substantially cylindrical front frame unit **12** that is disposed in a state of being close to the outer peripheral surface side of the substantially cylindrical first lens group unit **11**.

As shown in FIG. 6, the first lens group unit **11** has a substantially cylindrical outer peripheral surface **11a**, a large diameter portion **11b** having a larger outside diameter than the outer peripheral surface **11a**, a plurality of rectilinear keys **11c**, and a thin-walled portion (first thin-walled portion) **11d** (see FIG. 8A, etc.).

The outer peripheral surface **11a** is formed such that the large diameter portion **11b** is integrated at the end on the subject side and the plurality of rectilinear keys **11c** are integrated at the end on the image plane side.

The large diameter portion **11b** is disposed on the subject side of the first lens group unit **11** in the optical axis direction, and its outside diameter is larger than the inside diameter of the front frame unit **12**. Therefore, when the front frame unit **12** is mounted on the first lens group unit **11**, mounting from the subject side is impossible, and mounting from the image plane side is essential.

The plurality of rectilinear keys **11c** are formed so as to protrude outward in the radial direction from the outer peripheral surface **11a** on the image plane side of the lens **L1** in the optical axis direction.

More precisely, the plurality of rectilinear keys **11c** include the first rectilinear key **11ca** shown in FIGS. 7A to 7C and FIGS. 8A and 8B, and the second rectilinear key **11cb** and the third rectilinear key **11cc** shown in FIGS. 9A and 9B. The three rectilinear keys **11ca** to **11cc** are disposed on the outer peripheral surface **11a** of the first lens group unit **11** at equal angular intervals of about 120 degrees in the circumferential direction when viewed from the optical axis direction. Furthermore, as shown in FIGS. 9A and 9B, the three rectilinear keys **11ca** to **11cc** are disposed at mutually different positions **P1** to **P3** in the optical axis direction on the outer peripheral surface **11a** of the first lens group unit **11**.

The first rectilinear key **11ca** is disposed at the upper part of the outer peripheral surface **11a** of the substantially cylindrical first lens group unit **11** in the state shown in FIGS. 8A and 9A, etc. The first rectilinear key **11ca** is disposed at a position opposite the thin-walled portion **11d** (discussed below) in the radial direction. In an attached state, the first rectilinear key **11ca** moves in a state of being engaged with a substantially L-shaped first rectilinear groove **16ba** (see FIG. 10A) formed in the inner peripheral surface of the main body portion **16a** of the exterior unit **16** (discussed below).

In the state shown in FIGS. 8A and 9A, etc., the second rectilinear key **11cb** is disposed at a position approximately 120 degrees from the first rectilinear key **11ca** along the circumferential direction of the outer peripheral surface **11a** of the substantially cylindrical first lens group unit **11**.

In an attached state, the second rectilinear key **11cb** moves in a state of being engaged with a substantially Z-shaped second rectilinear groove **16bb** (see FIG. 10B) formed in the inner peripheral surface of the main body portion **16a** of the exterior unit **16** (discussed below).

In the state shown in FIGS. 8A and 9A, etc., the third rectilinear key **11cc** is disposed at a position approximately 120 degrees from the first rectilinear key **11ca** along the circumferential direction of the outer peripheral surface **11a** of the substantially cylindrical first lens group unit **11** in the opposite direction from that of the second rectilinear key **11cb**. In an attached state, the third rectilinear key **11cc** moves in a state of being engaged with a substantially

Z-shaped third rectilinear groove **16bc** (see FIG. 10C) formed in the inner peripheral surface of the main body portion **16a** of the exterior unit **16** (discussed below).

As shown in FIG. 8A, the thin-walled portion **11d** is a portion of reduced wall thickness of a substantially cylindrical member formed on a portion on the outer peripheral surface side that is opposite the first rectilinear key **11ca** in the radial direction. The thin-walled portion **11d** forms a specific gap **G**, which is required for offset attachment, between its own outer peripheral surface side and the inner peripheral surface of the front frame unit **12**.

More specifically, the thin-walled portion **11d** is provided on the outer peripheral surface **11a** of the first lens group unit **11** over a range of more than about 180 degrees, opposite the first rectilinear key **11ca** in the radial direction.

Consequently, the front frame unit **12** can move to the state of being offset shown in FIG. 8B, so that the front frame unit **12** rides up and over the first rectilinear key **11ca** without interfering with the first rectilinear key **11ca** in the optical axis direction.

Also, a recess is formed in which the thin-walled portion **11d** its width in the optical axis direction is a width **w** represented by the following relational expression (1).

$$\text{Width } w = \text{width of first rectilinear key } 11ca + \text{width of front frame unit } 12 \times 2 \quad (1)$$

The front frame unit **12** has an inside diameter that is smaller than the outside diameter of the first lens group unit **11** in the portion where the rectilinear key **11c** is provided. This means that some kind of measure must be taken in order to dispose the front frame unit **12** on the outer peripheral surface **11a** of the first lens group unit **11**, such as fitting the parts together while avoiding the plurality of rectilinear keys **11c** provided on the outer peripheral surface **11a** of the first lens group unit **11**, or using a front frame unit **12** that is made up of a plurality of parts.

In view of this, with the lens barrel **10** in this embodiment, as shown in FIGS. 8A and 8B, the first lens group unit **11** and the front frame unit **12** are formed at positions opposite the rectilinear key **11c** in the radial direction, so that a gap **G** is formed between the outside diameter and the inside diameter of the front frame unit **12**.

That is, the gap **G** is formed between the thin-walled portion **11d** formed by the recess on the outer peripheral surface side of the first lens group unit **11**, and the inner peripheral surface of the front frame unit **12**.

With the lens barrel **10** in this embodiment, offset attachment is performed by using the gap **G** to offset the first lens group unit **11** downward as shown in FIG. 8B, so that the front frame unit **12** rides up and over the first rectilinear key **11ca** formed so as to protrude outward in the radial direction from the outer peripheral surface **11a** of the first lens group unit **11**.

More specifically, in attaching the front frame unit **12** to the outer peripheral surface **11a** of the first lens group unit **11**, if an attempt is made to attach the front frame unit **12** just as it is, the first rectilinear key **11ca** will interfere with the front frame unit **12** because this key protrudes as shown in FIG. 7A.

In view of this, with the lens barrel **10** in this embodiment, the first lens group unit **11** is offset downward in FIG. 7B by using the gap **G** formed between the inner peripheral surface of the front frame unit **12** and the thin-walled portion **11d** formed at a position that is opposite, in the radial direction, the first rectilinear key **11ca** on the outer peripheral surface **11a** of the first lens group unit **11**.

Consequently, as shown in FIG. 7C, the front frame unit 12 rides up and over the first rectilinear key 11ca without any interference, moving from the state shown in FIG. 4A to the state shown in FIG. 4B (subject side), allowing the front frame unit 12 to be attached to the outer peripheral surface 11a of the first lens group unit 11.

At this point, the width of the thin-walled portion 11d in the optical axis direction forms a recess having a width w represented by the above-mentioned relational expression (1).

Consequently, the front frame unit 12 can move to a position where it has ridden up and over the first rectilinear key 11ca in the optical axis direction.

That is, the front frame unit 12 can ride up and over the first rectilinear key 11ca formed so as to protrude outward in the radial direction from the outer peripheral surface 11a of the first lens group unit 11. Therefore, even when the front frame unit 12 has an inside diameter that is smaller than the outside diameter of the first lens group unit 11 in the portion where the rectilinear key 11c is provided, the front frame unit 12 can be attached to the outer peripheral surface of the first lens group unit 11 as shown in FIG. 4B.

As a result, in the lens barrel 10 constituted by a combination of a plurality of cylindrical parts, fewer parts are needed than with a conventional configuration.

Also, as shown in FIGS. 26A to 26C, the front frame unit 12 has an inside diameter that is larger than the circumscribed circle of the first lens group unit 11 in a plane perpendicular to the center axis O of the substantially cylindrical first lens group unit 11, including the rectilinear key 11c of the first lens group unit 11, and is less than twice the length from the center axis O of the substantially cylindrical first lens group unit 11 to the outer surface of the rectilinear key 11c.

More specifically, in order to attach the front frame unit 12 to the outer peripheral surface 11a of the first lens group unit 11 shown in FIG. 26A, the front frame unit 12 is configured such that its inside diameter satisfies the following conditions.

That is, as shown in FIG. 26B, the inside diameter of the front frame unit 12 is larger than the diameter of the circumscribed circle of the first lens group unit 11 in a plane perpendicular to the center axis O of the substantially cylindrical first lens group unit 11, including the rectilinear key 11c of the first lens group unit 11.

Furthermore, as shown in FIG. 26C, the inside diameter of the front frame unit 12 is less than twice the length R from the center axis O of the substantially cylindrical first lens group unit 11 to the outer surface of the rectilinear key 11c.

Thus, the inside diameter of the front frame unit 12 satisfies the following relation:

$$\text{Diameter of circumscribed circle in FIG. 26B} < \text{inside diameter of front frame unit 12} < R \times 2 \text{ in FIG. 26C}$$

As a result, in the lens barrel 10 constituted by a combination of a plurality of cylindrical parts, the above-mentioned configuration in which the front frame unit 12 has an offset attachment structure with respect to the first lens group unit 11 means that fewer parts are needed than with a conventional configuration.

(3) Attachment Structure for Front Frame Unit 12 and Exterior Unit 16 to First Lens Group Unit 11

Next, the structure by which the front frame unit 12 is attached to the outer peripheral surface 11a of the first lens group unit 11 (see FIG. 4B), after which the exterior unit 16

is attached to the outer peripheral surface 11a of the first lens group unit 11 is as described below.

With the lens barrel 10 in this embodiment, as described above, three rectilinear keys 11c (first, second, and third rectilinear keys 11ca, 11cb, and 11cc) are provided at equal angle intervals of about 120 degrees are formed at different positions P1, P2, and P3 in the optical axis direction on the outer peripheral surface 11a of the first lens group unit 11 to which the exterior unit 16 is attached.

As shown in FIG. 5, these first to third rectilinear keys 11ca, 11cb, and 11cc move in a state of being engaged with grooves (first, second, and third rectilinear grooves 16ba, 16bb, 16bc) that have different shapes and are formed on the inner peripheral surface of the main body portion 16a of the exterior unit 16, when the exterior unit 16 is attached.

More specifically, the first, second, and third rectilinear grooves 16ba, 16bb, and 16bc have different shapes so as to correspond to the first, second, and third rectilinear keys 11ca, 11cb, and 11cc provided at different positions P1, P2, and P3 in the optical axis direction.

The first rectilinear groove 16ba is a groove with which the first rectilinear key 11ca is engaged, and as shown in FIG. 10A, is substantially L-shaped, including a rotation groove formed at the end on the subject side along the circumferential direction.

The second rectilinear groove 16bb is a groove in which the second rectilinear key 11cb is engaged, and as shown in FIG. 10B, is substantially Z-shaped and includes one rotation groove formed toward the image plane side by the distance between the positions P1 and P2, and two grooves that are formed in the optical axis direction and are connected respectively to the subject side and the image plane side of the rotation groove.

The third rectilinear groove 16bc is a groove in which the third rectilinear key 11cc is engaged, and as shown in FIG. 10C, is substantially Z-shaped and includes one rotation groove formed toward the image plane side by the distance between the positions P1 and P3, and two grooves that are formed in the optical axis direction and are connected respectively to the subject side and the image plane side of the rotation groove.

In attaching the exterior unit 16 to the outer peripheral surface of the first lens group unit 11, as shown in FIGS. 11A to 11C, the first, second, and third rectilinear keys 11ca, 11cb, and 11cc are inserted up to the portion of the rotation groove in the first, second, and third rectilinear grooves 16ba, 16bb, and 16bc, respectively.

Next, when the first lens group unit 11 is rotated from this state in the circumferential direction with respect to the exterior unit 16, the first, second, and third rectilinear keys 11ca, 11cb, and 11cc move along the circumferential direction in a state of being engaged with the rotary grooves in the first, second, and third rectilinear grooves 16ba, 16bb, and 16bc, respectively, as shown in FIGS. 12A to 12C.

At this point, rotation of the first lens group unit 11 in the circumferential direction with respect to the exterior unit 16 (see FIG. 20) produces a state in which the end of the exterior unit 16 on the subject side and the image plane side of the front frame unit 12 are fixed to each other.

Consequently, the exterior unit 16 is integrated with the front frame unit 12, resulting in a state in which the exterior unit 16 is attached on the outer peripheral surface of the first lens group unit 11.

The structure by which the exterior unit 16 and the front frame unit 12 are fixed to each other will be described in detail below.

11

In the state shown in FIGS. 12A to 12C, the exterior unit 16 is attached to the outer peripheral surface 11a of the first lens group unit 11, and as shown in FIGS. 13A to 13C, the first, second, and third rectilinear keys 11ca, 11cb, and 11cc are able to move back and forth in the optical axis direction in a state of being engaged with the groove portions along the optical axis direction in the first, second, and third rectilinear grooves 16ba, 16bb, and 16bc, respectively.

Here, the structure by which and the front frame unit 12 and the end of the exterior unit 16 on the subject side are fixed to each other in a state in which the exterior unit 16 is attached to the outer peripheral surface 11a of the first lens group unit 11 will be described below.

As shown in FIG. 14, in a cross-sectional view along the B-B plane in a state in which the exterior unit 16 is attached to the outer peripheral surface 11a of the first lens group unit 11, the front frame unit 12 is fixed to and integrated with the end of the exterior unit 16 on the subject side as shown in FIG. 15 and in FIG. 16, which is a detail view of the C portion in FIG. 15.

Here, as shown in FIG. 16, a grease pocket GP is disposed near a sliding face F1 where the front frame unit 12 and a focus ring 19b of the exterior unit 16 slide against one another.

As shown in FIG. 16, the grease pocket GP is a space formed to the radial inside of the sliding face F1 and is filled with grease as a lubricant.

Consequently, in a product such as a lens barrel 10, in which a ring such as a focus ring 19b is manually operated, a space in which grease is accumulated is provided near a sliding surface F1 provided between two substantially cylindrical parts, making it possible to control the amount of grease applied, which is indispensable for obtaining good tactile operation.

Also, since the grease pocket GP is provided more to the inside in the radial direction than the sliding surface F1, it excess grease can be prevented from leaking out to the visible outside part of the lens barrel 10.

As shown in FIGS. 17A to 17C, the front frame unit 12 has a main body portion 12a, a recess 12b, and latching tabs (latching portions) 12c.

The main body portion 12a is a substantially annular member, having an inside diameter that is smaller than the outside diameter of the first rectilinear key 11ca portion of the first lens group unit 11, and is slightly larger than the outside diameter of the portion where the first rectilinear key 11ca is not provided.

As shown in FIGS. 17A and 17B, the recess 12b is formed on the end surface on the image plane side of the substantially annular main body portion 12a, and engages with the first rectilinear key 11ca of the first lens group unit 11 in the formation of the structure for fixing to the end on the subject side of the exterior unit 16 (discussed below). Consequently, movement of the front frame unit 12 to the image plane side is restricted because relative rotation with respect to the first lens group unit 11 is impossible.

As shown in FIGS. 17A and 17B, three latching tabs 12c are provided on the inner peripheral surface of the substantially annular main body portion 12a at equal angular intervals of about 120 degrees. As shown in FIG. 17C, the latching tabs 12c are formed so as to protrude radially inward from the inner peripheral surface, running in the circumferential direction on the inner peripheral surface of the substantially annular shape. The latching tabs 12c engage with tab portions 16d provided on the exterior unit 16 side to form a structure for fixing to the end on the subject side of the exterior unit 16.

12

As shown in FIG. 18, the exterior unit 16 includes the substantially cylindrical main body portion 16a, the above-mentioned first to third rectilinear grooves 16ba to 16bc (see FIGS. 10A to 10C, etc.), an end portion 16c, and the tab portions 16d.

The end portion 16c and the tab portions 16d, which protrude outward in the radial direction from the outer peripheral surface at the end portion 16c of the main body portion 16a, are provided to the end on the subject side of the substantially cylindrical main body portion 16a.

As described above, the first to third rectilinear grooves 16ba to 16bc are formed on the inner peripheral surface of the substantially cylindrical main body portion 16a. The first, second, and third rectilinear grooves 16ba, 16bb, and 16bc then move back and forth in the optical axis direction in a state of being engaged with the groove portions along the optical axis direction in the first, second, and third rectilinear keys 11ca, 11cb, and 11cc, respectively.

The end portion 16c is a substantially cylindrical portion provided on the subject side of the substantially cylindrical main body portion 16a, and is fixed to the front frame unit 12 attached to the outer peripheral surface 11a of the first lens group unit 11.

Three of the tab portions 16d are provided at equal angle intervals of approximately 120 degrees on the outer peripheral surface of the end portion 16c of the main body portion 16a so as to engage with the three latching tabs 12c provided on the front frame unit 12 side (described above). The tab portions 16d are formed so as to protrude radially outward from the outer peripheral surface of the end portion 16c along the circumferential direction.

This mutual fixing structure between the exterior unit 16 and the front frame unit 12 first forms a state in which, as shown in FIG. 19, the front frame unit 12 is attached to the outer peripheral surface of the first lens group unit 11 by the above-mentioned offset attachment, and in this state the first rectilinear key 11ca of the first lens group unit 11 is engaged with the recess 12b of the front frame unit 12.

While still in this state, as shown in FIG. 19, the exterior unit 16 is inserted so that the inner peripheral surface of the exterior unit 16 is disposed close to the outer peripheral surface 11a side of the first lens group unit 11.

At this point, since the first rectilinear key 11ca is engaged with the recess 12b in the D portion of FIG. 19, the front frame unit 12 is phase-aligned in the rotation direction.

Next, in this state, as shown in FIG. 20, when the first lens group unit 11 is rotated in the direction of the one-dot chain line arrow (counterclockwise) in the drawing, since the first rectilinear key 11ca is engaged with the recess 12b of the front frame unit 12, the front frame unit 12 rotates integrally along with the rotation of the first lens group unit 11.

Here, because of the relative rotation operation of the first lens group unit 11 with respect to the exterior unit 16 shown in FIG. 20, the integration of the front frame unit 12 and the exterior unit 16 is carried out simultaneously with the attachment of the front frame unit 12 and the exterior unit 16 to the first lens group unit 11.

That is, prior to the relative rotation operation of the first lens group unit 11 with respect to the exterior unit 16 shown in FIG. 20, the first to third rectilinear keys 11ca to 11cc of the first lens group unit 11 are disposed in the rotary groove portions of the first rectilinear grooves 16ba to 16bc formed on the inner peripheral surface of the exterior unit 16, as shown in FIGS. 11A to 11C.

The relative rotation operation of the first lens group unit 11 with respect to the exterior unit 16 shown in FIG. 20 then causes the first to third rectilinear keys 11ca to 11cc of the

group unit **11** to move along the rotation grooves of the first rectilinear grooves **16ba** to **16bc** formed on the inner peripheral surface of the exterior unit **16**, as shown in FIGS. **12A** to **12C**.

For example, as shown in FIG. **21**, the first rectilinear key **11ca** moves in the direction of the one-dot chain line arrow in the drawing along the portion of the rotary groove in the first rectilinear groove **16ba**.

Consequently, the first to third rectilinear keys **11ca** to **11cc** of the first lens group unit **11** move to the rectilinear portion on the inside, formed along the optical axis direction of the first to third rectilinear grooves **16ba** to **16bc** on the exterior unit **16** side, which results in a state in which movement is possible the optical axis direction, as shown in FIG. **22**.

Furthermore, at this point, the relative rotation operation of the first lens group unit **11** with respect to the exterior unit **16** shown in FIG. **20** causes the three tab portions **16d** provided at the end portion **16c** of the exterior unit **16** to engage with the latching tabs **12c** of the front frame unit **12**.

Consequently, the exterior unit **16** is fixed with respect to the front frame unit **12** in the optical axis direction and is in an integrated state.

Therefore, the first lens group unit **11** can move back and forth in the optical axis direction with respect to the integrated front frame unit **12** and the exterior unit **16**, and is housed on the inner peripheral surface side of the exterior unit **16**.

Attachment Structure of FPC**20**

With the lens barrel **10** in this embodiment, as shown in FIG. **23**, the circuit board **21** disposed on the image plane side, and a rotation detection element **22** of the focus ring **19b** disposed on the subject side are connected via an FPC (flexible printed circuit) **20** disposed on the outer peripheral surface of the exterior unit **16**.

The FPC **20** is a printed circuit board that is flexible and is formed, for example, from a resin such as polyimide, and as shown in FIG. **24A**, has a flat portion **20a**, a bent portion **20b**, an extra length portion **20c**, and connecting portions **20d** and **20e**. As shown in FIG. **23**, the FPC **20** is fixed to the outer peripheral surface of the exterior unit **16** by a support portion **23** so that a part of the FPC **20** does not lift up from the outer peripheral surface of the exterior unit **16** as the first lens group unit **11** moves back and forth in the optical axis direction.

The flat portion **20a** is attached to the outer peripheral surface of the main body portion **16a** of the exterior unit **16**, and is disposed on the image plane-side portion of the FPC **20**.

The bent portion **20b** is a portion that connects the flat portion **20a** and the extra length portion **20c**, and is disposed in the approximate center of the FPC **20**. The bent portion **20b** is bent so that the flat portion is at approximately 90 degrees with respect to the flat portion **20a**, which puts the extra length portion **20c** in a state of standing up with respect to the outer peripheral surface of the exterior unit **16**.

More specifically, as shown in FIG. **24B**, the bent portion **20b** is such that the two branched portions coming from the flat portion **20a** are each bent at about 90 degrees from a state in which the FPC **20** is deployed, putting the extra length portion **20c** in a standing state.

The extra length portion **20c** has a plane substantially perpendicular to the outer peripheral surface of the exterior unit **16** because the bent portion **20b** is bent at approximately 90 degrees. Also, the extra length portion **20c** deforms so as to bend as the first lens group unit **11** of the lens barrel **10**

moves back and forth in the optical axis direction, and is housed in the interior of the lens barrel **10**, including this bending portion.

Also, as shown in FIG. **23**, the end portion (near the bent portion **20b**) of the extra length portion **20c** on the image plane side is fixed to the outer peripheral surface of the exterior unit **16** by the support portion **23** so as not to lift up from the outer peripheral surface of the exterior unit **16** when the first lens group unit **11** moves back and forth in the optical axis direction.

The connecting portion **20d** is formed in a state of being bent at the end portion on the image plane side of the flat portion **20a**, and is electrically connected to the circuit board **21** disposed on the image plane side.

The connecting portion **20e** is formed in a state of being bent at the end portion on the subject side of the extra length portion **20c**, and is electrically connected to the rotation detection element **22** of the focus ring **19b** disposed on the subject side.

In the lens barrel **10** in this embodiment, the FPC **20** has the extra length portion **20c** because of component tolerance, attachment variation, variance in connector position, and other such factors related to variance, and therefore the length of the FPC **20** varies.

In this embodiment, the FPC **20** is bent by about 90 degrees at a position near the approximate center.

Consequently, the extra length portion **20c** of the FPC **20** caused by component tolerance and other such variance prevents bulging out to the radial side (the first lens group unit side), which eliminates the risk of malfunction of the lens barrel **10** caused by disconnection of the FPC **20** due to contact with the first lens group unit moving along the optical axis direction, etc.

Appendix 1

The lens barrel **10** disclosed herein comprises:

a substantially cylindrical first frame;

a substantially cylindrical third frame on the inner peripheral surface side of which the first frame moves relatively in the optical axis direction; and

an FPC that is provided to the outer peripheral surface of the third frame and electrically connects a first component provided on the subject side in the optical axis direction and a second component provided on the image plane side,

wherein the FPC has a flat portion that is attached to the outer peripheral surface of the third frame, an extra length portion generated in the optical axis direction, and a bent portion that is disposed at a position connecting the flat portion and the extra length portion and that is bent such that the extra length portion forms a plane of approximately 90 degrees with respect to the flat portion.

Consequently, the extra length portion of the FPC generated by variance such as component tolerance prevents bulging out to radial side (the first frame side), which eliminates the risk of malfunction of the lens barrel **10** caused by disconnection of the FPC **20** due to contact with the first frame moving along the optical axis direction, etc.

Appendix 2

The lens barrel **10** disclosed herein comprises:

a substantially cylindrical first member;

a substantially cylindrical second member that is disposed near the first member and rotates so as to slide with respect to the first member; and

a grease pocket that is a space formed near the sliding surface on which the first member and the second member slide against each other, and that supplies grease to the sliding surface.

15

Consequently, in a lens barrel that includes manually rotated members, a space that holds grease is provided near the sliding surface provided between two substantially cylindrical parts, so the applied amount of grease, which is indispensable to good tactile operation, can be controlled.

Also, the grease pocket is preferably provided to the inside of the sliding surface in the radial direction.

This makes it possible to prevent excess grease from leaking out to the visible external portion of the lens barrel.

Other Embodiments

An embodiment of the present disclosure was described above, but the present disclosure is not limited to or by the above embodiment, and various modifications can be made without departing from the gist of the disclosure.

(A)

In the above embodiment, an example was given in which a gap G for offset attachment was formed between the outside diameter of the first lens group unit (first frame) **11** and the inside diameter of the front frame unit (second frame) **12**, at a position opposite the first rectilinear key (protrusion) **11ca** in the radial direction, by means of the thin-walled portion **11d** for reducing the outside diameter of the first lens group unit (first frame) **11**, but the present disclosure is not limited to this.

For example, as shown in FIG. 27, the configuration may be such that the gap G for offset attachment is formed between the outside diameter of a first lens group unit (first frame) **111** and the inside diameter of a front frame unit (second frame) **112**, at a position opposite a rectilinear key (protrusion) **111c** in the radial direction, by means of a thin-walled portion (second thin-walled portion) **112d** for increasing the inside diameter of the front frame unit (second frame) **112**.

(B)

In the above embodiment, an example was given in which a gap for offset attachment was formed between the outside diameter of the first lens group unit (first frame) **11** and the inside diameter of the front frame unit (second frame) **12**, at a position opposite the first rectilinear key (protrusion) **11ca** in the radial direction, by means of the thin-walled portion **11d** for reducing the outside diameter of the first lens group unit (first frame) **11**, but the present disclosure is not limited to this.

For example, the configuration may be such that a portion of the first frame opposite the rectilinear key in the radial direction is modified so that its outside diameter decreases so as to form a gap for offset attachment between the outside diameter of the first frame and the inside diameter of the second frame.

Alternatively, the configuration may be such that a portion of the second frame opposite the rectilinear key in the radial direction is modified so that its inside diameter increases so as to form a gap for offset attachment between the outside diameter of the first frame and the inside diameter of the second frame.

(C)

In the above embodiment, an example was given in which three first to third rectilinear keys **11ca** to **11cc** were provided on the outer peripheral surface of the first lens group unit (first frame) **11** at equal angle intervals of about 120 degrees, but the present disclosure is not limited to this.

For example, one, two, or four or more rectilinear keys may be provided on the outer peripheral surface of the first frame.

16

Also, the rectilinear keys do not need to be provided at equal angle intervals, and may be provided at unequal angle intervals.

(D)

In the above embodiment, an example was given in which the first to third rectilinear keys **11ca** to **11cc** were molded integrally with the first lens group unit (first frame) **11**, but the present disclosure is not limited to this.

For example, the rectilinear keys may be provided as separate components with respect to the first frame.

Here again, after the rectilinear keys have been attached to the outer peripheral surface of the first frame, the second frame can be attached offset.

(E)

In the above embodiment, an example was given in which the thin-walled portion **11d** was formed over a range of approximately 180 degrees opposite the first rectilinear key **11ca** in the first lens group unit (first frame) **11**, but the present disclosure is not limited to this.

For example, the range of the first thin-walled portion may be smaller than a range of approximately 180 degrees, or larger than approximately 180 degrees, so long as the gap required for the offset attachment of the first frame and the second frame is formed.

(F)

In the above embodiment, an example was given in which the configuration of the present disclosure was applied using the first lens group unit **11** as the first frame and the front frame unit **12** as the second frame, but the present disclosure is not limited to this.

For example, in a configuration of a lens barrel that is deployed in two stages, the configuration of the present disclosure may be applied using a drive frame disposed in the middle of this two-stage deployment as the first frame, and the front frame as the second frame.

(G)

In the above embodiment, an example was given in which the FPC **20**, in which the bending direction of the extra length portion **20c** was defined, was provided to the outer peripheral surface of the exterior unit **16**, but the present disclosure is not limited to this.

For example, the FPC provided to a lens barrel formed by combining a plurality of substantially cylindrical members is not limited to being on the outer peripheral surface of the exterior unit, and may instead be provided to the outer peripheral surface or the inner peripheral surface of some other cylindrical member.

(H)

In the above embodiment, an example was given in which the grease pocket GP for supplying grease to the sliding surface F1 between the focus ring **19b** and the front frame unit **12** was provided to inside of the sliding surface F1 in the radial direction, but the present disclosure is not limited to this.

For example, the position where the grease pocket is provided is not limited to the sliding surface between the focus ring and the front frame unit, and may instead be to the inside in the radial direction of the sliding surface over which other members slide.

INDUSTRIAL APPLICABILITY

An effect of the lens barrel disclosed herein is that fewer number parts are required as compared with a conventional lens barrel constituted by a combination of a plurality of cylindrical parts, which means that this invention can be widely applied to various kinds of lens barrel.

17

The invention claimed is:

1. A lens barrel, comprising:
 a substantially cylindrical first frame that holds a lens, the first frame including an image plane side and a subject side in relation to an optical axis direction; and
 a substantially cylindrical second frame having an inside diameter and which is disposed in a state of encircling an outer peripheral surface side of the substantially cylindrical first frame on the subject side,
 the first frame has a protrusion on the image plane side, the protrusion extending outward in a radial direction from an outer peripheral surface of the first frame,
 the first frame and the second frame are formed so that a gap is formed on the image plane side between the outside diameter of the first frame and the inside diameter of the second frame at a position opposite the protrusion in the radial direction,
 whereby a distance between the outside surface of the first frame at the gap and an outermost surface of the protrusion in a direction orthogonal to the optical axis is less than the inside diameter of the second frame,
 a diameter of the outer peripheral surface side of the first frame on the subject side is less than the inside diameter of the second frame, and
 the inside diameter of the second frame is less than a sum of the diameter of the outer peripheral surface side of the first frame on the subject side and an amount by which the protrusion extends radially from the outer surface of the first frame on the image plane side.
2. The lens barrel according to claim 1,
 wherein the first frame further has a first thin-walled portion at a position opposite the protrusion in the radial direction, whose thickness is less than the thickness around the protrusion and which reduces the outside diameter of the first frame.
3. The lens barrel according to claim 2,
 wherein the second frame has a substantially circular shape.
4. The lens barrel according to claim 2,
 wherein the first thin-walled portion is formed within a range of approximately 180 degrees opposite the protrusion in the radial direction.
5. The lens barrel according to claim 1,
 wherein the second frame further has a second thin-walled portion whose thickness is less than the thickness

18

6. The lens barrel according to claim 1,
 wherein the second frame is larger than a circumscribed circle of the first frame in a plane perpendicular to a center axis of the substantially cylindrical first frame, which includes the protrusion of the first frame, and has an inside diameter that is less than twice a length from the center axis of the first frame to an outer surface of the protrusion.
7. The lens barrel according to claim 1,
 wherein the protrusion is molded integrally with the first frame.
8. The lens barrel according to claim 1,
 wherein a plurality of the protrusions are provided on the outer peripheral surface of the first frame.
9. The lens barrel according to claim 8,
 wherein the plurality of protrusions are provided at substantially equal angular intervals on the outer peripheral surface of the substantially cylindrical first frame.
10. The lens barrel according to claim 9,
 wherein three of the plurality of protrusions are provided at equal intervals of approximately 120 degrees.
11. The lens barrel according to claim 8,
 wherein the plurality of protrusions are provided at mutually different positions in the optical axis direction.
12. The lens barrel according to claim 1,
 wherein the first frame further has a large diameter portion that is larger than the inside diameter of the second frame on a subject side in the optical axis direction.
13. The lens barrel according to claim 1,
 further comprising a substantially cylindrical third frame that is disposed in a state of being close to an outer peripheral surface side of the first frame, and is mated with and fixed to the second frame.
14. The lens barrel according to claim 13,
 wherein the third frame has a groove portion that is formed on an inner peripheral surface side along the optical axis direction and that engages with the protrusion of the first frame.

* * * * *